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Identification Manual for Phytoplankton of the United States Atlantic Coast

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IDENTIFICATION MANUAL FOR PHYTOPLANKTON OF THE UNITED STATES ATLANTIC COAST

by

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FOREWORD

Environmental measurements are required to determine the quality of ambient water, the character of effluents, and the effects of pollutants on aquatic life. The Environmental Monitoring and Support Laboratory - Cincinnati conducts research to develop, evaluate, and promulgate methods to:

- Measure the presence and concentration of physical, chemical and radiological pollutants in water, wastewater, bottom sediments, and solid waste.
- Concentrate, recover, and identify enteric viruses, bacteria, and other microorganisms in water.
- Measure the effects of pollution on freshwater, estuarine, and marine organisms, including the phytoplankton, zooplankton, periphyton, macrophyton, macroinvertebrates, and fish.
- Automate the measurement of the physical, chemical, and biological quality of water.
- Conduct an Agencywide quality assurance program to assure standardization and quality control of systems for monitoring water and wastewater.

The effectiveness of measures taken to maintain and restore the biological integrity of the Nation's surface waters is dependent upon our knowledge of the changes in the taxonomic composition of aquatic life caused by discharges of toxic substances and other pollutants, and upon the level of our understanding of the complex relationships that prevail in aquatic ecosystems. The phytoplankton play a key role in coastal waters because they often serve as the base of the food chain and are an important source of atmospheric oxygen. The abundance, species composition, and diversity of phytoplankton are sensitive to pollutants and are useful in detecting and quantifying adverse effects of pollutants on the biological integrity of marine ecosystems. Taxonomic keys and related reference materials for the phytoplankton are widely scattered in the scientific literature, thereby complicating the task of identifying the organisms and interpreting the data. This manual was developed to serve as a companion to the (1973) USEPA Biological Field and Laboratory Methods Manual, and was prepared to expedite the analysis of samples collected in marine biomonitoring programs in the Atlantic coastal waters by consolidating the keys for the identification of the common species of marine phytoplankton in a single, easily-used reference.

Robert L. Booth
Director
Environmental Monitoring and
Support Laboratory - Cincinnati

PREFACE

Phytoplankton comprise a diverse assemblage of mostly microscopic flora that inhabit the marine and fresh waters of the earth. Through their photosynthetic activities they generate oxygen and represent the primary producers in the majority of food cycles in water based ecosystems. They may also be responsible for contributing to adverse environmental conditions associated with toxin production, hypoxia, or anoxia. In addition, specific phytoplankton populations and assemblages have been used as indicators to various types of water masses, or water quality conditions. The importance of phytoplankton to the eastern coastal waters of the United States and the increasing interest directed to this community, were the major reasons for preparing this identification manual to the more common forms found in this region.

The purpose of this manual is to provide a general reference to Atlantic coast phytoplankton for technical personnel, and others, that do not have formal professional training in phytoplankton taxonomy. There are numerous identification keys in this field; however, many are not readily available, and several are in languages other than English. In addition, due to the numerous phylogenetic groups in this category, an extensive reference library is generally required. In preparing this manual, several of the more universally accepted references were used as the basis for the descriptions and illustrations. However, this manual is not intended to be an all inclusive reference or a substitute to many of the classical keys available in phytoplankton systematics. To the contrary, it is hoped that through this introduction, individuals will become more interested in phytoplankton studies, seeking out the original literature and eventually other identification keys. Several of these references have been provided in a later section.

The selection of the species presented in this manual came from the data files of the author encompassing 20 years of phytoplankton studies along the eastern continental shelf waters of the United States. The most frequently encountered phytoplankters were selected, along with several species and representatives from groups considered characteristic to this region. It should be understood that each area along the east coast may at times be represented by a diverse number of species, including many not represented in this reference. Particularly, coastal sections under the influence of river outflow and shoreline drainage may sporadically, or seasonally contain an assortment of other species. Even with these exceptions, the species presented in this manual are intended to provide the more characteristic phytoplankters in the waters of the U.S. eastern continental shelf.

The reader is cautioned that a considerable amount of reorganization has taken place within phytoplankton systematics over the past decade. As a point of reference, the author has elected to mainly follow the classification system suggested by Hendey (1974), Parke and Dixon (1976, and Van Landingham (1967-1978). The reader should understand that parts of this system may not correspond to those accepted by other authors and that systematic revisions are continuously in progress.

It should also be recognized that the eastern coast of the United States is an extensive, dynamic, and diverse region, with a continental shelf that is generally broad and subject to numerous environmental variables that will influence the presence and development of phytoplankton. These variables include the climatic factors associated with the subtropical conditions in the southern portion to the impact of colder, boreal waters from the north. Within this area occur a variety of current systems and other phenomena that produce Gulf Stream rings, various upwelling regions and outflow from major estuaries. The phytoplankton of this region is composed predominantly of diatoms, dinoflagellates, cyanobacteria, and prymnesiophyceans. Concentrations are highest nearshore and in association with upwelling areas or major estuaries. The Chlorophyceae, Cryptophyceae, and Euglenophyceae are also common, and frequently found in high numbers. Generally, total concentrations decrease across the shelf, rising again at various sites along the shelf margin, with Georges Bank representing an area of high productivity (Marshall, 1984). Seasonal changes in the abundance and composition of phytoplankton assemblages are characteristic of the northeastern sections, with Cape Hatteras a geographic reference for generally dividing, but not restricting, the development of many of the northern and southern species. For this eastern shelf region of the United States, over 700 phytoplankton species have been identified (Marshall, 1980).

Lastly, when the author originally began this manual, he was asked to include approximately 100 phytoplankters that would characterize the populations for the eastern shelf waters of the United States. He gradually added species, until the total number increased to 173. Although the inclusion of additional species would still be appropriate, there comes the time when the adding of yet another species becomes impractical due to budgetary and time restraints. Readers may also prefer original illustrations and additional coverage of those taxonomic groups that were only superficially covered in this manual. The use of illustrations from other references was a choice to reduce cost and expedite the manual's completion. Restriction in the scope of coverage for the various categories was mainly a response to the initial intent of the project and that the manual was not intended to be an all inclusive reference for each category, or for both estuarine and shelf species. More could also be said about phytoplankton assemblages associated with specific water masses, composition of estuarine plumes, and seasonal successional patterns for the geographic regions included in this manual. However, neither were these tasks or an indepth coverage of the various phytoplankton categories part of the original assignment, and the author regrets the absence or brevity given to these categories. For this reason, additional emphasis was placed on providing an expanded reference section, where the reader may obtain further information and address topics beyond the original intent of this manual.

Harold G. Marshall

ABSTRACT

This identification manual is designed for general usage by individuals who have not had formal training in phytoplankton systematics or access to the numerous keys and taxonomic references usually necessary to identify marine phytoplankton. This manual contains 173 species, representing 9 taxonomic groups, that the author considers among the more common species found on the United States eastern coast. The user is also provided with a list of additional identification references for the major taxonomic groups, phytoplankton studies for the United States east coast, and recommended collection and preparation techniques.

CONTENTS

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The phytoplankton data base represents collections from 30 cruises in the NOAA sponsored Ocean Pulse/NEMPS and MARMAP Programs between 1969 and 1982 and from 13 cruises aboard the Duke University R/V EASTWARD, between 1964-1972. Appreciation is given for the assistance provided in all of the cruises and to a cadre of exceptional graduate research assistants over the years who have made various contributions to this total phytoplankton effort. All samples were analyzed at the Old Dominion University Phytoplankton Laboratory, Norfolk, Virginia.

SECTION 1

INTRODUCTION

An identification key is provided for the major phytoplankton groups. Once the species group is established, the identification key for that category may be used to bring the user to a specific genus, and direct reference to species described in the manual. The description given for each species includes its dimensions and general distribution in the United States eastern coastal and shelf waters.

This area represents the region between Cape Canaveral, Florida and Nova Scotia, including the Gulf of Maine. Although several common estuarine species are also given, the manual is not intended to be a reference for the various estuarine systems along the east coast. The dimensions given for each species represent general ranges associated with growth patterns throughout the year and in most cases include other geographic areas of the world oceans. Local species should correspond to these sizes, but will not necessarily encompass the entire range of dimensions. No attempt is made to provide a synopsis of geographic ranges in world seas for these species. Rather, descriptions are given to characterize each species (e.g. oceanic, neritic, estuarine, tropical, temperate, etc.) with general comments as to occurrence and expected concentrations. In cases where the name has been changed, or is in question, an asterisk has been placed after the scientific name, with the name that was replaced given below in parenthesis.

It is assumed that most users will be working with preserved samples containing a single, but common phase of the phytoplankter's life cycle. Unfortunately with many of the phytoflagellates, considerable distortion and loss of flagella are associated with preservation, so the examination of live cells is often necessary for identification. Difficulties also arise in distinguishing many of the species that have not been processed or cleared through careful preparatory procedures. In addition, many groups require electron microscopy before an accurate identification can be made. In these cases additional methodology beyond the objectives of this manual would be required. Several references involving procedures and additional identification keys have been provided in the reference section. The readers are recommended to review collection and preservation procedures (e.g. in Sournia, 1978) to select the methods most appropriate in their work.

SECTION 2

PHYTOPLANKTON CATEGORIES

Phytoplankton systematics has undergone major revision over the past several decades. Many of these taxonomic changes have been based on the results of more refined biochemical assays of pigments and metabolic by-products, and by previously unknown morphological features revealed through electron microscopy. However, the literature still contains many differences of opinion on the classification of the phytoplankton groups. Revisions within several categories are still in progress, and include the reclassification of Cyanophyta as cyanobacteria (Stanier et al., 1971), and numerous generic and species reclassifications in other categories.

The user of this manual should realize a considerable range of morphological variation occurs commonly among the phytoplankton. For example, the shape and size relationships of certain structures may not conform precisely to the illustrations given for that species. These morphological differences may be due to genetic or environmental factors, or both. In many phytoplankters there appear to be growth variations in response to temperature, resulting in "cold water" forms that frequently differ from their "warm water" counterparts in the development of spines and other extremities (the former generally being shorter). In others, the differences between cold and warm water forms of the same species may be more subtle, as in the coccolith basal plate structure of *Emiliania* (Coccolithus) *huxleyi* (McIntyre and Bé, 1976). Sexual dimorphism is another source of size variation noted in some phytoplankton.

Even though one can often recognize such variations in form and development, the user of this manual is cautioned not to "force" an unknown organism into a particular species designation. Frequently, the phytoplankter can be identified only to genus, and if a species determination is necessary, a sample can be forwarded to an expert for species verification. In such cases, making illustrations, or taking photographs with the accompanying dimensions for any questionable species should become common practice in phytoplankton studies. Many investigators retain their original samples in a suitable preservative or make a reference slide for subsequent analysis of these populations.

Collections may also contain a variety of non-phytoplankton organisms and other particulate matter that were present within the water column. Common zooplankters often include tintinnids and copepods at near shore locations, with a variety of stages of different larval types and adults over the entire shelf. Fungal spores, debris, pollen and relict skeletal structures of diatoms are also frequently noted.

The phytoplankton categories included in this manual are the following.

I. Chrysophyceae
   A. Bacillariophyceae (Diatoms)
   B. Chrysophyceae (Golden Algae)

II. Dinophyta (Pyrrhophyta)
   A. Dinophyceae (Dinoflagellates)

III. Haptophyta
   A. Prymnesiophyceae (Haptophyceae)

IV. Cyanophyta
   A. Cyanobacteria (Cyanophyceae, Myxophyceae, Bluegreen Algae)

V. Cryptophyta
   A. Cryptophyceae (Cryptomonads)

VI. Chlorophyta
   A. Chlorophyceae (Green Algae)
   B. Prasinophyceae (Prasinophytes)

VII. Euglenophyta
   A. Euglenophyceae (Euglenoids)

SECTION 3

IDENTIFICATION KEYS

MAJOR PHYTOPLANKTON CATEGORIES

1a. Cells solitary, colonial, or filamentous. Non-filamentous cells spherical to elongate, often in gelatinous matrix; without chloroplasts or nuclei, pigments diffused, usually blue green, olive-green, or brown in color; in many filaments cell widths larger than their length; filaments may be separate, or in bundles -------------------------- Cyanobacteria

1b. Not as above -- 2

2a. Cells green, with one or more chloroplasts and nucleus ---------- 3

2b. Cells not green, may be yellow-green, brown, reddish-brown, yellow-brown; possess chloroplasts ---------------------- 5

3a. Cells with one or more green chloroplasts, a cell wall and starch reserve ---------------------------------- Chlorophyceae

3b. Green unicells, motile, with flagella arising from either a gullet or a depressed, lobed area ---------------------------- 4

4a. One or two flagella attached at anterior end, flagella associated with a gullet or furrow; fusiform, cylindrical, or ovoid in shape, chloroplasts usually abundant -- Euglenophyceae

4b. One to eight flagella arising from a depressed, often lobed area of the cell. Cell shape globular, or pyramidal -- Prasinophyceae

5a. Cells with one or more flagella -------------------------------- 6

5b. Cells without flagella -- 9

6a. Mostly flagellate unicells, possess two dissimilar flagella and a distinct nucleus, cells generally spherical, oval, flattened, or needle-shaped, often with spines, horns or other structures; some have a plate like armored pattern, some a transverse restriction (girdle) around the cell that contains the flagellar insertions -------------------------------- Dinophyceae

6b. Cells not as above -- 7

7a. Flagellated unicells, having two flagella that are equal or slightly unequal in length, cell shape is oval, or asymmetric and flattened, an anterior reservoir is often present ----------------------------- Cryptophyceae

7b. Cells not as above -- 8

8a. Mainly unicellular nanoplankters, motile and non-motile cells, most contain external scales visible with electron microscopy, some possess ornate coccoliths over outer cell -------------------------- Prymnesiophyceae

8b. Motile and non-motile cells occurring singularly or in colonies. Bi-flagellate cells usually have flagella of unequal length inserted laterally and at oblique angle to each other. Several species have scales. In the silicoflagellates, a rhomboid or hexagonal shaped skeleton is present ---------------- Chrysophyceae

9. Unicellular, filamentous or colonial cells composed of two overlapping valves of silica; usually circular, oval, rod, or boat shaped. In single cells, two views (valve and girdle) dissimilar. Valve sculpture has a radiating pattern that is centrally or laterally oriented, or is associated with a median line showing bilateral symmetry. In colonial forms, spines or thread-like cell connections are common -- Bacillariophyceae

BACILLARIOPHYCEAE

1a. Cells with valves that are linear, elliptical, sigmoid, lanceolate, may have a true raphe or cleft on one or both valves (Pennales) --------------------------- 2

1b. Cell valves without a raphe, have markings with a radiating orientation, often around a central point, valve outline usually circular, or oval; some cells are elongated and tubular; cells singularly or in chains (Centrales) ---------------------------- 17

2a. Valves without a true raphe on both valves, some have pseudoraphe, rectangular to rod shaped in girdle view --- 3

2b Possesses a true raphe -- 11

3a. Cells in a band, zigzag, or star-like formation ----------------- 4

3b. Cells not as above -- 10

4a. Cells in star shaped patterns ------------------------------------ 5

4b. Cells in zigzag or band like formation --------------------------- 6

5a. Linear, valve view shows one end rounded, other
wedge-shaped --- *Thalassiothrix*

5b. Spirally twisted colonies, cells linear with
dissimilar ends -- *Asterionella*

6a. Cells forming zigzag patterns ------------------------------------ 8

6b. Cells in band-like arrangement ----------------------------------- 9

8a. Valve view linear, girdle view oblong, distinct
intercalary bands, possess internal septa ------------- *Grammatophora*

8b. Cells linear, girdle view, elongated, rectangular,
with rounded ends ------------------------------------- *Thalassionema*

9a. Valves lanceolate, cells with rectangular-tabular
appearance, lack internal septa; punctae
interrupted at the center ------------------------------ *Plagiogramma*

9b. Valves linear lanceolate, surface punctate, with
irregularly scattered pattern ---------------------------- *Cymatosira*

10a. Valves lanceolate, or lanceolate rhombic, with
pseudoraphe, and punctae common -------------------------- *Rhaphoneis*

10b. Valves elliptical, narrow hyaline space or pseudo-
raphe on epivalve; straight raphe on hypovalve ------------ *Cocconeis*

11a. Possess raphe within a keel -------------------------------------- 15

11b. Raphe is not within a keel --------------------------------------- 12

12a. Valves linear, lanceolate, or oval, and punctate;
possess straight raphe -- 13

12b. Valves and raphe sigmoid -- 14

13a. Valves constricted in the middle -------------------------- *Diploneis*

13b. Valves possess distinct striae ---------------------------- *Navicula*

14a. Valve striae transverse and longitudinal ------------------ *Gyrosigma*

14b. Valve striae oblique and transverse --------------------- *Pleurosigma*

15a. Cells singular, valve oblong, tapering into hair-like spines -- *Cylindrotheca*

15b. Cells singular or in colonies ----------------------------------- 16

16a. Cells in colonies, valve view linear, girdle view rod-like, rectangular; live cells have gliding movement over adjacent cells ---------------------- *Bacillaria*

16b. Occur singular or as short, rigid chain of cells, marginal keel --- *Nitzschia*

17a. Cells single, or in chains, valves oval to polygonal, valves possess processes, or large spines ---------------------- 20

17b. Not as above --- 18

18a. Cells elongate, or tubular, with valves circular or oval; single or in chains; intercalary bands often noted -- 31

18b. Not as above --- 19

19a. Cells single, valves circular to oval; disc, rectangular, or drum shaped ------------------------------------- 36

19b. Cells may be single, but usually in chains, disc or cylindrically shaped, valves circular; cells may be connected by one or more thread-like connections to form a chain, or chains may lack connecting threads --- 39

20a. Possess long setae, cells connected in chains at the base of the setae -------------------------------- *Chaetoceros*

20b. Not as above --- 21

21a. Valves circular, with setae directed outward from valve margin -- 33

21b. Possess thick setae, spines, horns, or slight to long processes, valves circular to oval, or polygonal; may be united at ends of horns or processes to form chains -- 22

22a. Ribbon-like pattern of chain formation, girdle view square, cells flat, subdued processes -------------- *Streptotheca*

22b. Not as above --- 23

23a. Bipolar, with valve processes, apertures mainly oval to narrow elliptical, in short chains --------------------- 24

23b. Not as above -- 26

24a. Cells flat, marginal processes large, hammer-like ends, apertures broad oval to rectangular ------ *Climacodium*

24b. Not as above -- 25

25a. Wedge-shaped cells, flat, with thick processes, chains often twisted or curved. Apertures between cells narrow elliptical -- *Eucampia*

25b. Cells united in chains, in contact at centers and corners, small apertures near margins --------------------- *Bellerochea*

26a. Cells cylindrical, valves circular with two short, blunt processes near margin, connecting adjoining cells --- *Cerataulina*

26b. Not as above -- 27

27a. Valves may have long processes and spines, cells single or in chains -- 28

27b. Valves having 3 or more angles and a central spine ------------- 30

28a. Each valve with two long processes tipped with a claw-like structure -- *Hemiaulus*

28b. Not as above -- 29

29a. Cells usually connected at one corner, valves triangular or quadrangular -------------------------------- *Biddulphia*

29b. Valves usually elliptical, possessing two elongated processes and two long spines ---------------------------------- *Odontella*

30a. Cell is prism shaped, 3-4 cornered, appears cylindrical, with a large straight spine arising from each valve --- *Ditylum*

30b. Valves triangular, cells forming straight chains, connected by central spine ------------------------------ *Lithodesmium*

31a. Cells single, or in straight or curved chains; with eccentric conical or sub-conical valves ending in a spine. Numerous intercalary bands common ---------------- *Rhizosolenia*

31b. Cells not as above --- 32

32a. Cells in chain connected by slender central spine, with marginal threads secreted between cells, valves depressed in center ------------------------------ *Schroderella*

32b. Cells not as above --- 34

33a. Terminal setae radiate outward and bifurcate ------------ *Bacteriastrum*

33b. Setae from both ends of cell directed in the same direction -- *Corethron*

34a. Singularly or in short chains, girdle view rectangular, numerous intercalary bands, with a marginal spur-like spine on valve surface ---------------- *Guinardia*

34b. Not as above -- 35

35a. Flat, circular valves, possessing a row of small marginal spines -- *Detonula*

35b. Cylindrical, very narrow cells in short chains -------- *Leptocylindrus*

36a. Surface of valve divided into radial sections, alternately raised and depressed ---------------------- *Actinoptychus*

36b. Valve surface not divided into radial sections ---------------- 37

37a. Disc shaped cells, possessing a wide and complete peripheral, ribbed extension -------------------------- *Planktoniella*

37b. Valves circular, but not as above ----------------------------- 38

38a. Valve surface flat, convex, or concave ---------------- *Coscinodiscus* (*Cyclotella, Thalassiosira*)

38b. Valve surface undulating ---------------------------------- *Cyclotella*

39a. Cells united in chains by one or more thread like connections between adjacent cells ---------------------------- 40

39b. Cells in a chain, not connected by thread like connections -- 43

40a. Cells united by single thread or in a gelatinous, fine thread-like mass ---------------------------------- *Thalassiosira*

40b. Cells in a chain united by numerous connecting threads -- 41

41a. Cells connected by marginal circle of long spines, cells mostly elliptical, or cylindrical ----------------- *Skeletonema*

41b. Cells connected by spines or threads not marginally located --- 42

42a. Cells oblong, oval, or circular; valves areolate, with cells in a chain connected by several spines ------ *Stephanopyxis*

42b. Cells rectangular, connected by numerous fine threads -- *Coscinosira*

43a. Cells disc shaped, valves distinctly punctate ---------------- *Paralia*

43b. Discoid; or globose, elliptical, or cylindrical ------------- *Melosira* (*Cyclotella*)

DINOPHYCEAE

1a. Possess flagellated vegetative cells ---------------------------- 2

1b. Vegetative cells not flagellated, cells fusiform, hyaline, with protoplasmic threads from nucleus to cell wall; produce flagellated reproductive stage -- *Pyrocystis*

2a. Flagella inserted apically -- 3

2b. Flagella inserted laterally -------------------------------------- 4

3. Cell flattened, some forms have an anterior spine, some with an anterior depression; cell cordiform, lanceolate, oval, or rotundate -------------------------- *Prorocentrum*

4a. Cells either tubular, ovate, sub-circular, or flattened; girdle anterior, with girdle and sulcus having distinct lists that are often supported by ribs or spines ------------------------------------- 5

4b. Cells not as above --- 7

5a. Cells elongated, with flattened anterior end and an extended hypotheca, tube-like ------------------------ *Amphisolenia*

5b. Cells not elongated, possess distinct lists -------------------- 6

6a. Epitheca small, girdle lists obliquely oriented with anterior list funnel shaped, and having support ribs ------ *Dinophysis*

6b. Girdle and sulcal lists large, with sulcal list often extended below antapex --------------------------------- *Ornithocercus*

7a. Cells thecate (with plates) -------------------------------------- 8

7b. Cells not thecate -- 12

8a. Possess distinct apical horn, with two antapical horns dissimilar in length and shape ------------------------ *Ceratium*

8b. Cell not as above --- 9

9a. Cell club to spindle shape, elongated, with small epitheca; girdle is distinct, broad, deep, and anteriorly placed; epitheca and hypotheca often acute with an antapical spine ------------------------------ *Oxytoxum*

9b. Cell not as above -- 10

10a. Cell shape generally spherical, but variable; girdle near equator displaced so right end is below left (a descending spiral; left handed), may have apical horn and antapical spines. Plate formula is 3-4', 0-4a, 6", 6c, 5-10s, 5-6"', 1 p 1"" (Taylor, 1976) -- *Gonyaulax*

10b. Cell not as above -- 11

11a. Cells round to top-shaped, some species have apical and antapical horns or spines; girdle usually equatorial, but may be displaced right or left handed (ascending or descending), epitheca and hypotheca approximately equal. Plate formula: 4', 2-3(4)a, 7", 5"', 2"" (Taylor, 1976) ------------------------- *Protoperidinium*

11b. Spindle-shape, with irregular outline, conical epitheca with acute antapex, girdle is equatorial, but displaced ½ girdle width. Plate formula: 4', 2a, 7", 5"', 2"" (Campbell, 1973) --------------------------- *Heterocapsa*

12a. Cell small, less than 18 µm, elliptical to arrowhead shape in outline, girdle wide; epicone conical to hemispherical, with smaller, rounded hypocone -- *Katodinium*

12b. Cell not as above -- 13

13a. Cell fusiform to ovate, girdle always displaced more than 1/5 body length, sulcus often extending on epicone -- *Gyrodinium*

13b. Cell spherical to biconical, girdle equatorial to sub-equatorial with or without slight left handed displacement (less than 1/5 body length), sulcus may extend on epicone ---------------------------------- *Gymnodinium*
Ptychodiscus

CYANOBACTERIA (Cyanophyceae)

1a. Unicellular, or colonial organization ---------------------------- 2

1b. Distinct filamentous form -- 8

2a. Cells separate, in a linear arrangement, enclosed in a sheath ------------------------------ *Johannesbaptistia*

2b. Cells not as above --- 3

3a. Cells within a gelatinous matrix ------------------------------- 4

3b. Gelatinous envelop thin, or absent; cells spherical oblong to cylindrical, have transverse division, cells small, 1.4-5.0 µm.---------------------------- *Synechococcus*

4a. Cells arranged in rows within matrix at right angles to each other, forming flat colonies ------------------- *Merismopedia*

4b. Cells not as above --- 5

5a. Cells clustered in matrix, spherical, ovoid, to pyriform, tendency for radial arrangement of cells -- *Gomphosphaeria*

5b. Cells not as above --- 6

6a. Cells closely surrounded by a muscilage envelope --------------- 7

6b. Cells loosely scattered in a muscilage envelope, shape spherical or elongated, often in dense concentrations ---- *Microcystis*

7a. Cells spherical to hemispherical after division, within a distinct non-vesicular sheath often in groups of 2-4 cells ------------------------------------- *Chroococcus*

7b. Cells spherical, possess concentric layers of muscilage envelopes --- *Gloeocapsa*

8a. Cells endophytic in diatoms -------------------------------- *Richelia*

8b. Cells not as above --- 9

9a. Trichomes spiral, lacking apparent cross walls ------------- *Spirulina*

9b. Filaments with cross walls ------------------------------------- 10

10a. Trichomes without heterocysts, or a visible sheath or gelatinous matrix ------------------------------------ *Oscillatoria*

10b. Trichomes with heterocysts, within a gelatinous matrix -- *Nostoc*

CHRYSOPHYCEAE

1a. Cell with siliceous skeleton ------------------------------------ 2

1b. Cell lacking siliceous skeleton --------------------------------- 3

2a. Skeleton box shaped; possess a basal ring that is quadrate, or rhombic, with usually spines at the corners -- *Dictyocha*

2b. Skeleton with basal and apical rings, joined by rays, with several spines extending outward from basal ring ---- *Distephanus*

3. Cell elliptical, spherical, to pyriform, with two unequal length flagella inserted anteriorly; one flagellum is longer than body length; posteriorly rounded -- *Ochromonas*

HAPTOPHYCEAE

The systematics of the species presented here are based on coccolith structure. Details of these structures can only be seen with electron microscopy. Light microscopy may allow certain genera to be recognized by the trained observer, with confirmation coming from sub-sample examination with an electron microscope.

1a. Cells possess placoliths -- 2

1b. Cells have other types of coccoliths ---------------------------- 3

2a. Cell spherical to sub-spherical, with oval placoliths, and a large elliptical central area, surrounded by T-shaped elements -- *Emiliania*

2b. Cell spherical to sub-spherical, placoliths circular, robust, 18-31 elements composing placolith in contact with suture line that is curved; small central pit-like depression at center of placolith -------------- *Cyclococcolithus*

3a. Cell spherical, with cyrtoliths that bear a long rod, or nail shaped extension rising perpendicularly from an oval basal plate of a cyrtolith -------------------- *Rhabdosphaera*

3b. Cell not as above --- 4

4a. Cell body cylindrical, with boat shaped scapholiths ---- *Calciosolenia*

4b. Cell body spherical, ovoid, to pyriform, with caneoliths --- *Syracosphaera*

CRYPTOPHYCEAE

1. Asymmetric body shape, two flagella inserted anteriorly, with rows of trichocysts along ventral furrow or gullet -- 2

2a. Gullet or furrow simple or rudimentary, lined with up to two rows of trichocysts ---------------------------- *Chroomonas*

2b. Gullet or furrow more developed, with three or more rows of trichocysts -- *Cryptomonas*

CHLOROPHYCEAE

1. Single spherical to ellipsoidal cells, with one parietal chloroplast --- 2

2a. Cell division into two daughter cells not enclosed by mother cell wall ------------------------------------- *Nannochloris*

2b. Cell division within mother cell wall, usually into four daughter cells, but may divide into 2, 4, 8, 16 or more cells before leaving mother cell ---------------- *Chlorella*

EUGLENOPHYCEAE

1. Free living, motile, single cell, without a capsule or cell wall, 1-2 flagella, inserted anteriorly, chloroplasts common; body shape ovoid, fusiform, to cylindrical, and elastic in living forms -------------------- 2

2a. Two flagella, originating in terminal reservoir ------------ *Eutreptia*

2b. Single flagellum arising from terminal reservoir ------------- *Euglena*

PRASINOPHYCEAE

1. Motile unicells; shape typically ovoid, pyramidal to cordate, and lobed; 1-8 flagella, may possess trichocysts, usually with one chloroplast, with stigma and pyrenoid present, granular ------------------------- 2

2a. Distinct lobes, cell shape elongated elliptical or pyramidal, with sides more straight, 4 anterior flagella -- *Pyramimonas*

2b. Slightly lobed, with area between lobes, oval shape, broadly rounded posterior, 4 anterior flagella ----------- *Tetraselmis*

SECTION 4

PHYTOPLANKTON DESCRIPTIONS

BACILLARIOPHYCEAE

Actinoptychus senarius Ehrenberg* (Figure 1)

Single-celled, circular in valve view, valve surface divided into six alternately raised and depressed sectors, having a small hexagonal central area and hexagonal areolae. Cell diameter 20-150 µm.

A cosmopolitan, neritic species, frequently noted along the east coast and over the shelf, but never in high concentrations. *(*A. undulatus* Bailey)

Asterionella glacialis Castracane* (Figure 2)

Cells united to form star-like, spiral colonies; commonly 6-20 cells to a colony; cells linear with dissimilar ends, the larger end having a triangular head, the other end rod-like. Length of valve 30-150 µm.

Estuarine-neritic, a widespread, and very common species. Often in very high concentrations during spring and fall. *(*A. japonica* Cleve et Muller)

Bacillaria paxillifer (Muller) Hendey* (Figure 3)

Cells colonial, or free, girdle view is long rod-like rectangular. Valve view linear, lanceolate. Keel, centrally located, with keel puncta 7-9 in 10 µm. Striae 20-21 in 10 µm. Living colony exhibits gliding movement, with cells sliding back and forth over each other. Length of valves 70-250 µm, width 5-6 µm.

Common coastal species, found in estuarine and neritic waters, but not in large numbers. *(*B. paradoxa* Gmelin; *Nitzschia paxillifer* (Muller) Heilberg)

Bacteriastrum delicatulum Cleve (Figure 4)

Cylindrical cells, connected by fused setae of adjoining cells to form short chains; connecting setae extend outward, bifurcate in a plane at right angles to pervalvar axis. Terminal setae do not bifurcate, are curved and directed toward inside of the chain. 6-12 setae present per cell. Cell diameter 6-40 µm, length 20-60 µm. Chains up to 20 cells. Valvular view often visible, showing radial pattern of setae.

Oceanic-neritic, commonly found in temperate waters over the shelf, but not in large concentrations.

Bellerochea malleus (Brightwell) Van Heurck (Figure 5)

Cells in flat chains, rectangular in girdle view, narrow, with adjacent cells in contact except for small apertures near the margins. Valves triangular with central area slightly raised with a ring of puncta. Valve width 80-110 µm, pervalvar axis 20 µm.

Neritic. Wide distribution in tropical and sub-tropical areas. Common in warm waters along southeast coast and in the Gulf Stream.

Biddulphia alternans (Bailey) Van Heurck* (Figure 6)

Cells single, or in chains, valve view triangular, with straight, or unevenly concave sides, girdle view rectangular; chains composed of cells united at one corner presenting girdle view. Cells also benthic, attached to substrate. Length of valve side 27-50 µm.

A neritic, widely distributed species more common near shore, but not in high concentrations. *(*Triceratium alternans* Bailey)

Cerataulina pelagica (Cleve) Hendey* (Figure 89)

Cells cylindrical, united to form short chains, with valves slightly rounded, and with two short processes connecting adjoining cells that are slightly separated. Valve diameter 11-56 µm.

Mainly a temperate, neritic-estuarine species, often common in shelf collections. *(*C. bergonii* (Peragallo) Schütt)

Chaetoceros affine Lauder (Figure 10)

Colonial, cells cylindrical, united to form chains, with girdle view rectangular. The valves are elliptical with a flat or weakly convex surface where corners touch adjacent cells, with delicate and almost straight setae. The aperture between the adjacent cells is narrow and elliptical. Terminal setae much larger, thicker and divergent. Both wide and narrow-width forms known. Valve diameter 7-30 µm.

A neritic-estuarine species, common in temperate to tropical waters, more abundant during warmer months.

Chaetoceros atlanticum Cleve (Figure 11)

Cells, rectangular in girdle view, forming short, straight chains. Valves slightly convex, with a small centrally located spine. Cell divided rather equally in thirds, composed of the two valve mantles, separated by the girdle, with presence of very slight constriction where girdle and valve mantle join. Setae arise within valve margin, are almost straight and are directed obliquely; terminal setae shorter than others, and slightly bent along axis of chain. Diameter 10-46 µm.

An oceanic species, wide-spread in colder waters of the North Atlantic and Arctic. Usually not found in large concentrations.

Chaetoceros coarctatum Lauder (Figure 12)

Cells cylindrical, united to form chains. Valves elliptical to circular, valve mantle and girdle area distinct. Cells and setae robust, setae arise from valve margin, extend outward at approximately right angles, about a third of their length they curve backwards; terminal setae distinct and thicker, posterior setae large, curved, horseshoe shaped, heavily spined, with anterior setae thick and spinal. Valve diameter 30-45 µm.

Oceanic, occasionally found over the shelf, being more common to subtropical and tropical waters, but not in large concentrations. Epiphytic protozoa (e.g. *Vorticella oceanica*) are often attached to the cells.

Chaetoceros compressum Lauder (Figure 15)

Cells rectangular in girdle view, united to form straight chains; setae delicate, arising from valve margin, crossing with setae from adjacent cell and then directed at right angles to chain axis. Apertures range from a slit to 4 or 6 sided opening. Valve diameter 10-30 µm.

Neritic-estuarine, with wide distribution but generally considered a cold water species more common to the northeastern shelf.

Chaetoceros concavicorne Mangin (Figure 13)

Cells united in colonies, or separate, with cells generally square to rectangularly shaped in girdle view; chains slightly twisted, valves dissimilar, epivalve rounded with setae arising near the valve center. The lower valve surface is flat, with setae coming from nearer the valve margin. The girdle area is distinct. Setae more narrow at their base, having small spines, and are directed, obliquely backward, with a slight bow over their length. Valve diameter 12-36 µm.

Oceanic-arctic species, more common to the colder north temperate and boreal shelf waters, but abundant.

Chaetoceros debile Cleve (Figure 14)

Cells united to form long twisted chains. The girdle view of the valve is rectangular, with a flat surface, a slightly raised margin, and four distinct corners bearing thin setae that tend to bend toward the same side of the chain. Adjoining cells are separated by a narrow oval aperture, being in contact at the cell margin, or base of the setae. Resting spores often found centrally located in the cells. Valve diameter 8-40 µm.

Neritic, north temperate species, common to colder shelf waters, often reaching high concentrations.

Chaetoceros decipiens Cleve (Figure 17)

Cells united to form straight, stiff chains. The girdle view is rectangular, with setae arising at right angles to the chain from a slightly raised valve margin; setae fusing together in pairs near the valves, then separate outward. The terminal setae at both ends of the chain are distinct, being thicker, and emerging from the valve in an oval pattern, with the setae eventually directed in an almost parallel direction along the chain axis. The apertures between cells will vary in their shape seasonally, being smaller and more linear in winter, and larger and more oval in summer. Valve diameter 10-80 µm.

Mainly an oceanic species, common in arctic, boreal, and north temperate waters; often reaching large concentrations; range extends to tropical waters.

Chaetoceros diversum Cleve (Figure 18)

Cells united in short straight chains. The girdle view is rectangular, with cells having two types of setae, each arising from the corners of the cell. One type is a thicker more heavy form, possessing fine spines and directed in a broad curve that is pointed in line with the chain axis; the other setae are thin, more delicate and directed in an oblique pattern. There is a very narrow, linear aperture between adjacent cells. The valves are elliptical, with the terminal setae directed outward, in the direction of the chain axis. Valve diameter 8-12 µm.

Neritic. Common to tropical and subtropical regions, and warmer waters over the shelf.

Chaetoceros lorenzianum Grunow (Figure 9)

Cells solitary or in short chains; rectangular in girdle view, with valve flat or raised slightly in the center. Setae long and stiff arising directly from valve surface, where they fuse with those of the adjacent cell, space between cells from elliptical to narrow hexagonal in shape. Setae divergent. Valve diameter 15-60 µm.

Neritic. Common in tropical to temperate waters, often noted in estuaries.

Chaetoceros peruvianum Brightwell **Not Illustrated**

Cell usually solitary; possessing long stiff setae, with setae arising from the central part of the epitheca, and occupying most of the valve surface; these setae turn abruptly and sweep backward. The hypothecal setae develop obliquely, with their ends usually divergent but some may converge. Setae usually with small spines. Valve diameter 10-44 μm.

Oceanic-neritic. Broad distribution in warm temperate to tropical waters.

Chaetoceros sociale Lauder (Figure 16)

Cells rectangular in girdle view, united in short, curved chains; often found together in mucilaginous colonies; setae often develop into long slender extensions that appear to hold cell clusters together. Apertures range from narrow to hexagonal. Valve diameter 6-12 μm.

Neritic, common from temperate to tropical waters.

Climacodium frauenfeldianum Grunow (Figure 19)

Cells flat, united into chains, possessing large, marginal processes that give each side a T-shaped appearance, and forming a large oval aperture between adjoining cells. Valve width (apical axis) 70-225 μm, across pervalvar axis 10-30 μm.

Oceanic-neritic, mainly a sub-tropical and tropical species, with wide distribution, but not abundant.

Cocconeis scutellum Ehrenberg (Figure 20)

Cells solitary, valves elliptical, dissimilar, with upper valve having a pseudoraphe and obvious punctae in transverse rows; the lower valve with marginal rim, median line with a small circular central area, and straight raphe. Valve length 45-60 μm, width 30-40 μm.

A widely distributed species, more common near shore along the east coast. Represented by several varieties.

Corethron criophilum Castracane* (Figure 21)

Cells usually solitary, cylindrical; possess dome-shaped valves (ends) that have a circle of delicate, and mainly straight, spines, radiating outward; the spines of both valves oriented toward the same valve. Valve diameter 12-60 μm, cell length (pervalvar axis) 40-240 μm.

Oceanic-neritic. More common to Arctic and north temperate waters. Frequently found in the eastern shelf waters from Maine to Florida, but not in large numbers. *(*Corethron hystrix* Hensen).

Coscinodiscus centralis Ehrenberg (Figure 22)

Cells discoid, with valves possessing radial areolation, and having a central rosette; areolae becoming smaller moving from the center outward, with 5-6 per 10 μm near the margin. Girdle view shows a narrow girdle section, composed of several girdle bands within the two convex valves. Small spinulae may also be found along valve margin. Valve diameter 100-300 μm, pervalvar axis 50-60 μm.

Neritic-oceanic. Generally a temperate species, common along the east coast.

Coscinodiscus concinnus W. Smith (Figure 23)

Large, single-celled species, drum-shaped in girdle view, with slightly convex, or flattened valves; delicate areolation over valve decreasing in size from the center outward, with 14-15 areolae occurring per 10 μm near margin; central area often appears "clear", with rosette not clearly visible or absent; valve margins have delicate spinulae from which extend hyalin lines to center of valve; girdle view shows several intercalary bands; often there are numerous small chromatophores present. Valve view diameter 200-500 μm, but mostly between 350-450 μm, with similar size for the pervalvar axis.

Neritic, temperate species, common in Gulf of Maine and the northeast coast where it often reaches high concentrations.

Coscinodiscus granii Gough (Figure 24)

Cells discoid, valves with delicate areolae and a central rosette; areolae radially oriented, becoming smaller from center outward with 11 occurring per 10 μm near margin. Distinctive feature is girdle view which is cuneate, with one side about twice as wide as the other. Valve view diameter 80-200 μm.

Neritic. A temperate species, with wide distribution. Found mainly in northeastern shelf waters.

Coscinodiscus lineatus Ehrenberg (Figure 25)

Cells discoid, valves flat to slightly convex, areolae appear to be in straight lines parallel to diameter, areolae slightly smaller near margin, ranging from 6 at the center to 7 per 10 μm at the margin; valve margin distinct and radially striated, marginal spinulae present. Valve view diameter 40-120 μm.

Oceanic-neritic. Wide distribution, common along the east coast, but not in high concentrations.

Coscinodiscus marginatus Ehrenberg (Figure 26)

Cells discoid, valves flat to slightly rounded, with large well-defined areolae, 2-3 occurring per 10 μm at center and 3-4 at the margin; margin is wide and radially striated. Valve view diameter 40-100 μm, but more frequently in lower half of this size range.

Oceanic-neritic. Wide distribution, frequently noted from east coastal waters, but not in large concentrations.

Coscinodiscus nitidus Gregory (Figure 27)

Cells discoid, valves generally flat, covered with large granules in an irregular pattern, being larger at the center and decreasing in size toward the margin; small punctae located radially near margin. Valve view diameter 25-75 μm.

Neritic. Wide distribution, but not in high concentrations in coastal waters.

Coscinodiscus oculus-iridis Ehrenberg (Figure 28)

Cells discoid, large, valves slightly convex, with large polygonal areolae and a central rosette usually composed of five, or less, large areolae. Other areolae at center 3½-4½ per 10 μm, to 2½-3½ near margin. Narrow margin with radial striation. Valve view diameter 120-260 μm.

Oceanic-neritic. Wide distribution, common in the northeastern coastal waters.

Coscinodiscus radiatus Ehrenberg (Figure 29)

Cells discoid, coin-shaped valves; thin in girdle view, flat, or slightly curvey, polygonal areolae in radiating pattern, with no rosette; areolae 3-4 per 10 μm, but smaller near margin, 6-7 per 10 μm. Valve view diameter 35-140 μm.

Oceanic and neritic. Wide distribution, being common in shelf waters, but not in large numbers.

Coscinodiscus wailesii Gran et Angst (Figure 30)

Cells cylindrical, large, drum-shaped, slightly concave, with broad mantle and girdle bands; valve areolae about 6 per 10 µm, no rosette, central area of valve clear, with radiating hyaline lines. Valve view diameter 230-350 µm.

Neritic species. Common along the east coast.

Coscinosira polychorda (Gran) Gran (Figure 31)

Cells cylindrical, rectangular in girdle view with rounded corners, cells united in loose chains by 4-9 gelatinous threads between adjacent valves, valves slightly convex with surface areolae 8-10 per 10 µm. Valve diameter 25-75 µm.

Neritic. North temperate species, widely distributed, but not in large numbers.

Cyclotella meneghiniana Kützing (Figure 36)

Cell drum-shaped, solitary or in a short chain; valve face in girdle view shows an undulating pattern where the margins of adjacent cells in a chain are in contact. Possess a marginal, striated zone containing 6-10 striae in 10 µm. Cell diameter 5-35 µm.

Estuarine. Mainly associated with near shore, littoral region, but sometimes noted in the estuarine and near shore neritic plankton of temperate waters.

Cyclotella striata (Kützing) Grunow (Figure 32)

Cells discoid, solitary, or in short chains of 2 or 3 cells, girdle view essentially rectangular, but showing the undulating pattern of the valve edge. Valve is circular, with surface having a diametrical fold and divided into central and marginal areas; the marginal area is about half the radius and is radially striated (8 striae per 10 µm). Valve diameter 20-60 µm.

Neritic-estuarine. A species often noted at near shore stations and in estuaries, along with *Cyclotella caspia* and *C. meneghiniana*.

Cylindrotheca closterium (Ehrenberg) Reiman et Lewin* (Figure 33)

Cells single, valve oblong, with ends tapering into fine hair-like spines that may be slightly curved; faint striation on valve, with two centrally located chromatophores. Length of valve 30-400 µm, more typically 125-150 µm.

Neritic-estuarine. Common in near shore waters; often abundant. Sometimes confused with *Nitzschia longissima*. *(*Nitzschia closterium* (Ehrenberg) Smith).

Cymatosira belgica (Grunow) (Figure 34)

Valves linear-lanceolate, small, with rounded apices; surface punctate in irregular transverse pattern. Linear in girdle view, with slightly inflated central and terminal sections. Spines present on valve surface. Valve length 12-30 μm, width 3-5 μm.

Littoral-neritic. Common at near shore stations near sandy beaches. Wide distribution along the east coast.

Detonula confervacea (Cleve) Gran (Figure 35)

Cells cylindrical, united in short chains. Valves circular, flat, with a marginal row of tooth-like spines. Cells one to three times longer than their width. Valve diameter 5-15 μm.

Neritic. Frequently noted near shore.

Diploneis crabro Ehrenberg (Figure 55)

Valves solitary, panduriform, elliptical-cuneate segments; valve surface costate, with costae alternating with double rows of small areolae; central nodule quadrate or sub-circular. Variations in shape and size common. Apical axis 35-150 by 35-60 μm in width.

Neritic. Found at near shore locations, but not abundant. Numerous varieties of this species are generally common.

Ditylum brightwellii (West) Grunow (Figure 37)

Cells elongated, appear cylindrical with rounded ends, but valve is prism shaped, 3 or 4 cornered, with rounded edges, 3-8 times as long as wide; each valve has one large, straight central spine, within a ring of smaller spines. Valve diameter 25-85 μm, pervalvar axis 80-130 μm, length of spine 20-50 μm.

Neritic species with wide distribution and common in shelf collections, but seldom abundant.

Eucampia zodiacus Ehrenberg (Figure 38)

Cells flat, united to form chains; spirally curved girdle view shows adjacent cells attached at outer cell margin by two stout processes, with narrow lanceolate to oval-shaped apertures between cells. Cell width 30-96 µm, pervalvar axis 40-50 µm.

Neritic-oceanic, with wide distribution, but usually in low concentrations.

Grammatophora marina (Lyngbye) Kützing (Figure 39)

Cells oblong in girdle view, united at ends to form chain with a zigzag pattern. Valves linear, with rounded ends, and striated. Valve length 60-80 µm, width 10-12 µm.

Littoral species. Widespread distribution, common in coastal waters.

Guinardia flaccida (Castracane) Peragallo (Figure 40)

Cells cylindrical, single or in short chains; girdle view rectangular, numerous intercalary bands, with adjoining cells in contact, valve surface nearly flat with characteristic marginal spur obvious in girdle view. Valve diameter 30-80 µm, pervalvar axis 45-160 µm.

Neritic, temperate species, common, but not found in high concentrations.

Gyrosigma balticum (Ehrenberg) Cleve (Figure 41)

Cells solitary, valves linear, elongate, sigmoid, with obtuse apices; raphe sigmoid and central, with a small and elliptical central region; valve surface striate with striae in transverse and longitudinal lines, 11-13 per 10 µm, with girdle narrow and plain. Valve length 240-500 µm.

Littoral species with wide distribution, common near estuaries.

Gyrosigma fasciola (Ehrenberg) Cleve (Figure 42)

Cells solitary, lanceolate, with attenuated ends, curved in the opposite directions and each comprising about 1/4 of the total cell length. Centrally located raphe, striated valve surface, with transverse and longitudinal striae; striae very fine, with transverse striae 21-24 per 10 µm. Valve length 100-300 µm, width 15-18 µm.

Neritic-estuarine. Wide distribution, common in coastal waters, but never abundant.

Hemiaulus hauckii Grunow (Figure 43)

Cells in chains, or solitary; in girdle view cells oblong, with long thin processes on each corner, each terminated with a spine, with the process parallel to pervalvar axis. Valve surface flat to slightly concave, with a wide mantle. Apertures between adjacent cells large and rectangular due to long connecting processes. Cell width (apical axis) 10-75 μm.

Mainly neritic, but also described as oceanic, found in tropical and temperate waters. Frequently noted over the eastern shelf, being more common south of Cape Hatteras, but not in high concentrations.

Hemiaulus sinensis Greville (Figure 44)

Cells typically united in chains, straight, or curved; valve view elliptical, generally oblong, slightly convex, with two stout processes located at either end of the cell, each process having a slight bend, but parallel to the pervalvar axis; valve mantle wide, having areolae in radial pattern that is off-center to center of the valve, 7-8 areolae per 10 μm. Cell width (apical axis) is 12-90 μm.

Neritic species, found occasionally over the shelf, but more often associated with tropical and temperate waters where it is common, but never abundant.

Leptocylindrus danicus Cleve (Figure 45)

Cells cylindrical, narrow and elongated in girdle view, united end to end in short, straight chains; cell length generally 2-5 times the diameter. Valves mainly flat, circular, and without spines. Numerous chromatophores common. Valve diameter 6-16 μm, pervalvar axis typically 30-60 μm, but may be longer.

Neritic and estuarine, with wide distribution along the east coast. A major dominant during spring and fall outbursts near shore and at the shelf margin, often a co-dominant with *Skeletonema costatum*.

Leptocylindrus minimus Gran (Figure 46)

Cells cylindrical and elongated, similar to *Leptocylindrus danicus*, but more narrow, possessing only two chromatophores. Chain of cells also tends to be slightly curved, thread-like. Valve diameter 3-6 μm, pervalvar axis 40-50 μm.

Neritic and estuarine species with wide distribution, often present with *Leptocylindrus danicus* during seasonal outbursts, where it may reach large concentrations.

Lithodesmium undulatum Ehrenberg (Figure 47)

Cells forming straight chains, held together by a central spine that connects the adjacent cells, with a conspicuous aperture between cells. Girdle view common, with cells rectangular, and the margin irregular. Valves triangular, with each side having an undulating pattern, and each valve with a centrally located spine. Valve surface possesses radially arranged areolae. Valve length (one side) 35-65 μm.

Neritic species, found more often south of Delaware Bay; occasionally abundant.

Melosira distans (Ehrenberg) Kützing (Figure 48)

Cells cylindrical, united to form short chains, length of cell slightly greater than width, puncta in longitudinal rows in girdle view. Valve diameter 4-20 μm.

A common freshwater species that occasionally is found in estuaries and river plumes over the shelf.

Melosira moniliformis (O. F. Muller) Agardh (Figure 53)

Cells short, cylindrical, united in chains; often seen during division with cells connected in pairs by the girdle. Valves circular, convex, with valves and girdle punctate. Valve diameter 23-60 μm.

Estuarine-neritic. A near shore species, common in estuaries, and often in estuarine plumes.

Melosira nummuloides (Dillwyn) Agardh (Figure 54)

Cells united in short chains; shape of frustules globose to slightly oblong; valves hemispherical, with fine puncta radially organized on the valve surface. Valve diameter 28-35 μm.

An estuarine-neritic species, often found near shore. Not found in high concentrations.

Nitzschia delicatissima Cleve (Figure 49)

Cells united in rigid chains, valves thin, needle-like, finely tapered; keel central with puncta small, 22-26 per 10 μm. Cells in girdle view narrowly rectangular. Cells in chain have short area where tips overlap. Valve length 55-90 μm, width 1.5-2.5 μm.

Neritic. Reported in temperate and subtropical areas along the east coast. Frequently confused with other *Nitschia* spp. Its status is in question, and may be composed of several species; including *N. delicatula* (see Hasle, 1965).

Nitzschia longissima (Brébisson) Ralfs (Figure 50)

Cells solitary, valves linear-lanceolate, with ends extended into long tapering processes. Marginal keel with keel puncta 6-10 per 10 µm. Valve length including processes 150-450 µm, more typically around 200 µm, 6-7 µm wide.

Neritic. Frequently noted in samples near the coastline. Often confused with the smaller *Cylindrotheca closterium*.

Nitzschia pungens Grunow* (Figure 51)

Cells linear-lanceolate, acute, united in rigid chains, with the ends of the cells overlapping approximately one-third their length (or more); in valve view both sides of central area convex, valve striae 11-16 per 10 µm; cells more pointed and narrow than *Nitzschia seriata*. Valve length 70-160 µm, width 2.3-4.8 µm.

Neritic-estuarine. Mainly a temperate species that is common and with a wide range along the east coast; often in high concentrations during spring and fall months. *(*N. pungens atlantica* Cleve).

Nitzschia seriata Cleve (Figure 52)

Cells spindle-shaped, united in rigid chains, with the tip of adjacent cells overlapping 1/4 to 1/3 their total cell length. In valve view the central part of the cell has one convex and one almost straight side, with the valve tapering to slightly rounded ends. The girdle view is linear to lanceolate. Keel eccentric, with puncta not obvious. Valve striae 14-18 per 10 µm. Valve length 80-148 µm, width 5.5-8 µm.

Neritic. More common to colder waters and the northeastern portion of the U.S. eastern shelf. May be confused with *N. pungens*.

Odontella mobiliensis (Bailey) Grunow* (Figure 7)

Cells single, rarely in chains, often seen as a two-celled unit after division. In girdle view, cell is rectangular to sub-octagonal in shape. Has wide girdle band; valves possess narrow tubular processes directed diagonally outward. The central valve area has two spines on each surface that are set apart from each other. Fine punctate markings on valve. Apical cell axis: 45-200 µm, breadth 50-90 µm.

Neritic. A temperate species frequently found in low concentrations. *(*Biddulphia mobiliensis* (Bailey) Grunow).

Odontella sinensis (Greville) Grunow* (Figure 8)

Cells single, or united by their spines to form short chains. Girdle view rectangular; valve surface slightly concave, having short processes, and two long spines arising close to the processes. Cell length 120-300 µm.

A widely distributed species, mainly found over the shelf in temperate waters, but not in high concentrations. *(*Odontella chinensis* (Greville) Grunow, *Biddulphia sinensis* Greville).

Paralia sulcata (Ehrenberg) Cleve* (Figure 56)

Cells discoid, dense, usually united to form short chains, directly connected valve to valve, girdle view showing distinct oblong pattern of cells within rectangular section of chain; end sections typically have an open, concave pattern of a single valve. Valves strongly marked with punctae. Valve diameter 36-60 µm.

Neritic-littoral species. Common, with a wide distribution in temperate and sub-tropical waters, but not in high concentrations. *(*Melosira sulcata* (Ehrenberg) Kützing).

Plagiogramma vanheurckii Grunow (Figure 57)

Cells usually united in short chains, with a rectangular-tabular appearance in girdle view with inflated ends. Valves lanceolate, decreasing in size from the middle to the ends. Valve width (apical axis) 20-35 µm, transapical axis 4-5 µm.

Littoral-neritic-estuarine. Widespread distribution, mainly in warm temperate waters, but not in high concentrations.

Planktoniella sol (Wallich) Shutt (Figure 58)

Cells solitary, disc-shaped, with central body of cell surrounded by wing-like expansion. Central body appears similar to *Thalassiosira eccentrica*, having convex valves with distinct polygonal areolation in tangentially curved lines. Valve diameter (central body) 30-180 µm, including wing, up to 360 µm.

Oceanic-neritic. Wide distribution in subtropical and tropical waters. Never abundant.

Pleurosigma aestuarii (Brébisson) W. Smith (Figure 59)

Cells solitary, valve lanceolate with sigmoid-shape, raphe centrally located, valve striae oblique and transverse with 20 per 10 µm. Valve length 84-148 µm, width 28-34 µm.

Neritic-estuarine. Common from temperate waters, but not in high numbers.

Pleurosigma angulatum (Quekett) W. Smith (Figure 60)

Cells free, valves rhomboid-lanceolate, sigmoid, with raphe central and sigmoid, central nodule small. Valve surface striate, with oblique and transverse striae, 18-22 per 10 µm. Valve length 120-280 µm, width 36-65 µm.

Neritic-estuarine. Common near shore in vicinity of estuaries and coastal marshes.

Pleurosigma obscurum W. Smith (Figure 61)

Cells free, narrow, slightly sigmoid, with bluntly rounded ends, and raphe sigmoid. Valve striae oblique and transverse, 25-30 per 10 µm. Valve length 90 120 µm, width 10-12 µm.

Neritic-estuarine. Found close to shore and near estuaries.

Pleurosigma strigosum W. Smith (Figure 62)

Cells solitary, valves lanceolate, sigmoid, with raphe sigmoid, central, but more eccentric toward the ends. Valve striae oblique and transverse, 18-22 per 10 µm. Valve length 160-300 µm, width 30-36 µm.

Neritic-estuarine. Common near shore in vicinity of estuaries.

Rhaphoneis amphiceros (Ehrenberg) Ehrenberg (Figure 63)

Cells single. Valves lanceolate, or lanceolate-rhombic, usually broad, with pronounced ends. Valve with pseudoraphe and large punctae on the surface in curved radiating lines, about 6 per 10 µm. Considerable variation in form. Valve length 40-45 µm.

Estuarine-neritic. Wide distribution. More common near shore.

Rhaphoneis surirella (Ehrenberg) Grunow (Figure 64)

Cells single, small, valves broadly elliptical to elliptical-lanceolate, with large puncta over valve surface in slightly curved radiating lines separated by a pseudoraphe which widens towards the end of the valve. Valve length 20-50 µm, width 12-26 µm.

Estuarine-neritic. Wide distribution, but more common near shore and by estuaries.

Rhizosolenia alata Brightwell (Figure 65)

Cells elongated, rod-shaped, straight, tubular, with valves conical and ending in a slightly curved process. Girdle represented by two dorsiventral rows of polygonal scale-like segments, with margins appearing as a zigzag line. Valve diameter 8-15 µm, length up to 1 mm.

Oceanic-neritic. Wide distribution and common along entire eastern shelf waters. Often in high concentrations.

Rhizosolenia alata f. *gracillima* (Cleve) Gran (Figure 66)

This form is very similar to *Rhizosolenia alata* except it is thinner, with the valves less conical and more extended. Valve diameter 4-6 µm, cell length up to 500 µm.

Neritic. A temperate species, common along the east coast.

Rhizosolenia alata f. *indica* (Peragallo) Gran (Figure 67)

Cells wider and shorter than *Rhizosolenia alata*. Apex of valves generally has a thin, curved process directed obliquely. Occasionally cell will have two different types of apical development, one like *R. alata*, the other like this form. Valve diameter 20-60 µm.

Oceanic-neritic. Frequently noted along the eastern shelf, but more common south of Cape Hatteras.

Rhizosolenia calcar-avis Schultze (Figure 68)

Cells cylindrical, elongated. Valves conical, slightly eccentric, each having an extended curved spine arising from the valve apex. The girdle band pattern is rhombic, scale like. Valve diameter 30-70 µm. Cell length up to 1 mm.

Oceanic-neritic. Widespread distribution in tropical and subtropical waters. Frequently found along the east coast.

Rhizosolenia castracanei Peragallo (Figure 69)

Cells large, cylindrical. Valves small, conical with apex terminated into a short spine, blunt and directed obliquely. Pattern of girdle scales wavey. Valve diameter 150-380 µm, length of cell 600-1000 µm.

Oceanic, tropical and subtropical. Found frequently in the Gulf Stream, but in low numbers.

Rhizosolenia delicatula Cleve (Figure 70)

Cells cylindrical, united in short straight chains; girdle view rectangular, valves joined by flat surfaces, but with slightly rounded corners, producing a slight indentation at the margin where two cells meet. Valves have a short, small marginal spine that fits into furrow of adjoining cell; this spine is usually noticeable on terminal valves of the chain. Valve diameter 12-20 µm, cell length (pervalvar) 40-60 µm.

Neritic. Temperate species, very common in the northeastern shelf waters, often in high concentrations during spring and fall outbursts.

Rhizosolenia fragilissima Bergon (Figure 71)

Cells cylindrical, united in short chains; girdle view slightly oblong, longer than it is wide, with the ends rounded. The valves are convex, with a short, centrally located spine, obliquely directed and fitting into a depression in the adjoining cell. Due to the structure and manner that the spines connect adjacent cells, the girdle view often shows a greater degree of indentation along one margin than the other. Girdle composed of ring-shaped bands that are usually difficult to see. Valve diameter 12-60 µm, cell length (pervalvar) 30-80 µm.

Neritic. Frequently found over the shelf, being more common nearer to the coast.

Rhizosolenia imbricata Brightwell (Figure 72)

Cells cylindrical, large, solitary, or in chains; valves conical, oblique and pointed by a distinct spine that appears as a continuation of the valve margin. The girdle view shows large scale-like bands that are directed around the cell. Valve diameter 25-100 µm, cell length 300-500 µm.

Neritic. Frequently noted in temperate and subtropical waters over the shelf.

Rhizosolenia robusta Norman (Figure 73)

Cells cylindrical, single or in short chains; valves conical with broadly curved ends, ending in a short spine. Girdle view often crescent-shape, with valve ends directed to the same side, or in an S-shape when pointed to opposite sides. Valve is striated longitudinally, with the girdle markings having a circular, ring-like pattern. Valve diameter 40-150 µm, cell length up to 500 µm.

Oceanic-neritic. Wide distribution, frequently noted over the shelf, but appears to be more common in warmer waters.

Rhizosolenia setigera Brightwell (Figure 74)

Cells rod-like, cylindrical, with each valve tapering into a long stiff spine that is usually straight. Valves are conical, but depending on the view, the direction of the valve spine and girdle pattern may vary. In a lateral view the spine is usually more obliquely directed and there is a zigzag plate pattern on the girdle, whereas a ventral or dorsal view would show more of a shield-like plate pattern. Valve diameter 6-25 μm, cell length up to 300 μm.

Neritic-estuarine. Widespread distribution in temperate waters, common along the east coast, often abundant.

Rhizosolenia shrubsolei Cleve* (Figure 75)

Cells cylindrical, single, or in chains, often flattened; valves conical, with one side as a straight continuation of the cell, the other side of the valve having an oblique pattern. The spine is short with small wings at its base, decreasing in size along the spine. The girdle scales show different patterns according to position of the cell; when the valve spine is centrally in line the plate margin presents a zigzag line, but where the spine is eccentric there is a ring-like pattern around the cell. Valve diameter 6-20 μm, cell length 300-500 μm.

Neritic. North temperate species, noted along the east coast, more common north of Cape Hatteras. *(*R. imbricata* var. *shrubsolei* (Cleve) Schröder)

Rhizosolenia stolterfothii Peragallo (Figure 76)

Cells cylindrical, elongated, curved, and united to form a curved chain. Valves flattened, with a small marginal spine that fits into a depression in the adjoining cell; there is a slight indentation along the chain margin where two cells meet. Girdle bands are faint and annular. Valve diameter 15-45 μm, cell length up to 250 μm.

Neritic, estuarine. Widely distributed, frequently found along the U.S. east coast.

Rhizosolenia styliformis Brightwell (Figure 77)

Cells cylindrical, straight, long, usually solitary. Valves obliquely conical, and possessing an apical spine. The cell margin generally appears as a continuous straight line running along the dorsal surface of the valve to the apical spine. The oblique plane of each valve bears a depression that is not apparent in the lateral view. This depression serves for the placement of the spine from an adjoining cell during cell formation. At its base, the spine has two small lateral wings. The girdle has two dorsiventral rows of scale-like plates, which in a lateral view appear in a zigzag pattern, but with rounded angles. Valve diameter 20-100 µm, cell length up to 1.5 µm.

Oceanic-neritic. A widely distributed species in north temperate waters. Common and often abundant over the eastern continental shelf. Of note is the cyanophycean endosymbiont, *Richelia intercellularis*, that is frequently found associated with this species (and several other *Rhizosolenia* spp.).

Schroederella delicatula (Peragallo) Pavillard* (Figure 78)

Cells cylindrical, usually elongated with length 2-5 times the breadth, forming straight chains. Variations in form occur in regard to the size of the cell and the distance between adjoining cells, with smaller sizes more prevalent in warmer waters. Valves circular, almost flat, distinctly depressed in the center, where a spine arises; other small, marginal spines encircle the valve and connect to spines from the adjacent cell. The girdle bands give a faint annular pattern around the cell. Valve diameter 18-42 µm, cell length (pervalvar axis) 16-100 µm.

Neritic. Frequently noted over the eastern continental shelf, but often confused with *Lauderia borealis*. More common in warmer waters *(*Detonula pumila* (Castracane) Schütt)

Skeletonema costatum (Greville) Cleve (Figure 79)

Cells generally cylindrical, or oblong, with rounded ends, joined by spine-like connections to form straight filaments. Space between cells is usually greater than the cell size. Variations in cell size common within a given sample and seasonally. Cell diameter 8-16 µm.

One of the most common and abundant neritic and estuarine species. High concentrations usually associated with estuaries, near shore locations, and during spring and fall outbursts. Found in lower concentrations at mid-shelf locations.

Stephanopyxis palmeriana (Greville) Grunow (Figure 80)

Cells cylindrical, oblong, or elliptical, in short chains; with a flat, or slightly convex valve, bearing stout marginal spines (10-22) that connect to those of adjoining cell. Valve areolae are hexagonal, slightly smaller near girdle, 1½-3 per 10 µm at valve center and 5-7 per 10 µm near girdle line. Valve diameter 35-150 µm.

Neritic-oceanic. Frequently found along the east coast, but more often in subtropical, or warmer waters. Sometimes confused with *Stephanopyxis turris*.

Streptotheca tamesis Shrubsole* (Figure 81)

Cells rectangular, almost square, flat, and united in a ribbon-like chain that is twisted along its length. Cells not separated in the chain, but have a small prominence on one valve that fits into a corresponding depression in the valve of adjacent cell. No aperture between adjoining cells. Valve diameter 40-100 µm.

Neritic. Widely distributed species, frequently noted over the shelf, but not in high concentrations. *(*S. thamesis*)

Thalassionema nitzschioides Hustedt (Figure 82)

Cells linear, straight, united to form zigzag chains. In girdle view, elongated rectangular, with rounded ends, cells connected at ends, often chain contains united pairs of recently divided cells. The range of cell length often results in either a long or a short form within the sample. Valve length 30-80 µm.

Neritic-estuarine. A common species with wide distribution in north temperate waters and along the east coast. Often found in high concentrations.

Thalassiosira eccentrica (Ehrenberg) Cleve* (Figure 83)

Cells discoid, valves almost flat, with beveled edges and a narrow margin bearing short apiculi. Valves have hexagonal areolae that are arranged in parallel and slightly curved rows. Areolae 7-8 per 10 µm at center of the valve and 10-11 per 10 µm near the margin. Valve diameter 40-120 µm.

Neritic-oceanic. Widely distributed and common along the east coast. *(*Coscinodiscus eccentricus* Ehrenberg)

Thalassiosira gravida Cleve (Figure 84)

Cells disc-shaped, united by a thick thread to form short chains. Girdle view rectangular, with rounded edges. Valves flat, with marginal spines, a central apiculus, with fine radial striation. Valve diameter 20-60 µm

Neritic. A widespread northern species, common in cold waters and areas north of Cape Hatteras.

Thalassiosira nordenskioldii Cleve (Figure 85)

Cells united in chains by a fine thread. In girdle view cells are short-rectangular, appearing octagonal due to distinctly beveled, or rounded corners. The valve is slightly convex, having a central depression, from which arise the central thread; marginal spines are also present. Valve diameter 12-40 µm.

Neritic. A cold water species common in the Gulf of Maine and a seasonal dominant north of Cape Hatteras.

Thalassiosira rotula Meunier (Figure 86)

Cells disc-shaped, united by a thick central thread to form short chains. Valves flat, slightly rounded at margins, lacking spines. Girdle view presents a rather flat, narrow, rectangular appearance, with a moderately wide space between adjacent cells. Valve diameter 30-50 µm.

Neritic. Cold water species, common dominant in northeastern coastal waters during winter and early spring.

Thalassiosira subtilis (Ostenfeld) Gran (Figure 87)

Cells discoid, single, usually found embedded in gelatinous mass. Valves round, having a convex surface, without distinct sculpture; one small spinula and one apiculus at valve margin. Girdle view shows annular segments. Valve diameter 15-32 µm; pervalvar axis 10-15 µm.

Oceanic-neritic. Frequently noted along the east coast. There are also several smaller (3-15 µm diam.) *Thalassiosira* spp. somewhat similar in shape, and some with threadlike extensions, that are found over the shelf with some present in estuaries (see Hasle, 1983). Included with these smaller species is *Thalassiosira oestrupii* var. *venrickae* reported in Chesapeake Bay and on the shelf (Marshall, 1984).

Thalassiothrix frauenfeldii Grunow (Figure 88)

Cells united into star-shaped colonies, girdle view is narrow-linear, with squared ends. Valve view is linear, with one end wedge-shaped, the other rounded; the valve surface has a marginal row of punctae. Valve length 80-120 µm, width 2-4 µm.

Oceanic-neritic. Widespread; north temperate to the tropics, found often in large concentrations.

CHRYSOPHYCEAE

Dictyocha fibula Ehrenberg (Figure 90)

Cell skeleton quadrate, or rhomboid, with spines at corners of the skeleton. A silicoflagellate. Skeleton 10-45 µm wide.

Oceanic-neritic. Widespread distribution found over entire continental shelf, but not in high concentrations. Skeletons more frequently noted than living specimens, especially in areas of upwelling, with numerous variations recognized.

Distephanus speculum (Ehrenberg) Haeckel* (Figure 91)

A silicoflagellate, with the basal ring of the skeleton hexagonal; the corners usually bearing spines. Inward pointing spines may also be present. Diameter of basal ring 30-40 μm.

Oceanic-neritic. Widely distributed over entire continental shelf, but usually in low concentrations. Both skeletons and living specimens common in some areas. Wide variation in skeletal structure. *(*Dictyocha speculum* Ehrenberg)

Ochromonas caroliniana Campbell (Figure 92)

Cells single, oval to pyriform, rounded posteriorly and truncated obliquely anteriorly; two unequal length flagella inserted in a slight depression anteriorly. Length 10-20 μm, width 8-11 μm.

Estuarine. The example given for this genus is usually associated with the smaller estuarine creeks and river systems.

DINOPHYCEAE

Amphisolenia bidentata Schröder (Figure 119)

Central body portion spindle-shaped, with anterior end slightly twisted and tapering, expanding to a head 2-3 times wider than long, epitheca usually convex. The posterior end is drawn out, slightly twisted, with an elbow-shaped bend near the end. Length 700-990 μm.

Oceanic. Wide distribution in tropical and subtropical waters. Often noted in near shore waters.

Ceratium arcticum (Ehrenberg) Cleve (Figure 93)

Body breadth similar to, or slightly greater than length. Horns divergent. Epitheca with sides convex and shorter than hypotheca, the apical horn strongly bent, with the antapical horns far apart, with the left horn having a slight curvature, and the right horn straighter; theca sculptured. Width of cell body 48-60 μm, length of apical horn 165-240 μm.

Oceanic and neritic. A widespread cold water form similar to *C. longipes*. Frequently found in the Gulf of Maine and northern shelf waters.

Care should be taken not to confuse this species with *C. longipes*. Note: Refer to the Glossary for definition of left and right sides of dinoflagellates.

Ceratium carriense Gourret (Figure 101)

Compact cell body, with long divergent antapical horns, greater than 60° from apical horn; apical horn is directed almost perpendicular to the plane of the girdle, with the left antapical horn having a bend slightly posteriorly from its base, then extending in a broad curve. The right antapical horn may be initially directed more laterally or posteriorly, then forming a broad curve. Width of cell body 60-92 µm, cell length 400-950 µm.

Oceanic. Tropical and the warmer coastal waters. This species is variable in its form and is often confused with *C. massiliense*.

Ceratium contortum (Gourret) Cleve (Figure 94)

Body slightly contorted, with the right antapical horn twisted, and directed inwardly, then toward end of apical horn; the epithecal contour on the right side is strongly convex and oblique, with the apical horn offset to the left and bent. Posterior base of cell is rounded (convex) with the non-twisted left horn curving in the direction of apical horn. Cell length 200-500 µm.

Oceanic. Widespread, tropical, warm water species. Variable forms.

Ceratium extensum (Gourret) Cleve* (Figure 95)

An elongated, needle-shaped cell, the cell body narrowly fusiform, with epitheca extended into long apical horn; it may be found with, or without the development of the right antapical horn. Most frequently it is absent, with the left antapical horn posteriorly directed and longer than the epitheca and the apical horn. When the right antapical horn is present, it is short; with the length of the left antapical horn and apical horn more similar in length. Cell body width 20-30 µm, cell length 500-1750 µm.

Oceanic. Widespread, tropical species, frequently noted, but not in high concentrations. *(*C. biceps* Claparede et Lachmann).

Ceratium furca (Ehrenberg) Claparede et Lachmann (Figure 96)

Cell linear, with epitheca gradually tapering from the girdle, without interruption along the apical horn. Considerable variability in form. Antapical horns mostly parallel, directed posteriorly, but dissimilar, with the right horn, which is often directed slightly outward. These antapical horns are often toothed. Cell body width 30-50 µm, cell length 100-280 µm.

Neritic, estuarine, oceanic. Widely distributed along the coast.

Ceratium fusus (Ehrenberg) Dujardin (Figure 97)

Needle-shaped, from almost straight to slightly bent cell. Epitheca long and tapering into extended and slightly bent apical horn. Hypotheca with left antapical horn usually longer than apical horn and epitheca, and slightly bent dorsally; the right antipical horn is absent, or rudimentary. Cell body width 15-30 μm, cell length 200-700 μm.

Oceanic. Widespread species, common in samples over the eastern shelf. Variations in form common.

Ceratium lineatum (Ehrenberg) Cleve (Figure 98)

Cell body longer than it is wide, epitheca triangular, then is extended into apical horn, giving "funnel" appearance, hypotheca more trapezoidal, with antapical horns divergent and dissimilar, with the right horn directed slightly outward and is 1/3-2/3 shorter than the left horn. Cell body width 25-47 μm, cell length 35-65 μm.

Oceanic, mainly a temperate and cold water species, often found, but not in large concentrations. Generally separated from *C. minutum* by its divergently oriented antapicals.

Ceratium longipes (Bailey) Gran (Figure 99)

Cell with strongly bent apical horn, epitheca slightly triangular, hypotheca with right antapical horn emerging directly below the girdle and bending toward the apical horn; the left antapical horn develops at a lower point below the girdle having a sharper bend, approaching the same direction as the apical horn. The horn curvature pattern presents a somewhat "streamlined" appearance. The posterior portion of the hypotheca is convex. The antapical horns are frequently toothed, with the theca sculptured. The orientation of the antapical horns and their more robust pattern distinguish this species from *C. arcticum*. Cell body width 50-60 μm, cell length 150-200 μm.

Oceanic-neritic. Temperate and cold water species common in Gulf of Maine and northeastern shelf waters. Often in high concentrations.

Ceratium lunula (Schimper) Jörgensen (Figure 102)

Apical horn of first cell in a chain longer than those of the other cells; apical horn centrally located; epitheca is triangularly shaped, hypotheca shorter with a straight posterior; antapical horns long, forming a broad curve, with ends slightly divergent or parallel to the apical horn. Width of cell body 85-100 μm.

Oceanic. Warm water species of wide distribution in tropical and sub-tropical waters. Variations in shape common.

Ceratium macroceros (Ehrenberg) Van Höffen (Figure 103)

Long-horned species, body compact, being longer than broad, with apical horn slender, slightly off-center, but with a broad base, usually straight, or slightly bent. Hypotheca longer than epitheca, with posterior area between horns rather straight and oblique. The antapical horns extend outward approximately a body width, then curve anteriorly and often in parallel to the apical horn. The left antapical horn is posteriorly directed before forming its curve, with the right antapical horn emerging nearer the girdle than the left horn and is first outwardly directed, then curves anteriorly to form a broad curve. A posterior list is frequently found at the base of the left antapical horn. A variety associated with this species is var. *gallicum* (Fig. 103b), being smaller with shorter and more abruptly curved antapicals. Cell body width 45-60 (100) μm.

Oceanic. Temperate to tropical species, with wide distribution, commonly found on the eastern continental shelf.

Ceratium massiliense (Gourret) Karsten (Figure 104)

Large, long-horned species, shape variable, with several associated forms recognized. Epitheca with convex sides and long apical horn that bends slightly posteriorly. Hypothecal base straight, or slightly convex, with the left antapical horn directed posteriorly, then bending anteriorly. The right antapical horn arises nearer the girdle, then bends inward. The bases of the antapical horns are approximately at right angles to each other. The antapicals may be wavy, with their ends inwardly curved. Small fins may be present at the base of the apical horn as well as, small spines along the posterior margin of the antapicals. Cell body width 60-85 μm.

Oceanic-neritic. Widely distributed species, common in tropical and sub-tropical waters. Often noted in Gulf Stream.

Ceratium minutum Jörgensen (Figure 100)

Small, ovoid in shape; epitheca rounded, tapering into a short apical horn, hypotheca trapezoidal with a straight angled base, with antapical horns of unequal length; the right antapical horn being shorter and not well developed. Cell body width 25-58 μm.

Wide distribution. Noted in shelf waters usually in low concentrations.

Ceratium trichoceros (Ehrenberg) Kofoid (Figure 105)

Cell with three very long and thin horns, epitheca with slightly convex sides, with a centrally located straight apical horn. Hypotheca slightly shorter than epitheca, with a rather straight and oblique posterior and a fairly straight left side. The left antapical horn arises from a short basal piece dorsally to the left, then curves forward and apically. Both antapical horns extend in a broad curve in the direction of the apical horn, tending to bring all three horns parallel to each other. The ends of the antapical horns may be straight or wavy. Cell body width 37-48 µm. Length of apical horn 200-248 µm.

Tropical and sub-tropical species. Wide distribution, but not in high concentrations.

Ceratium tripos (O. F. Muller) Nitzsch (**Figure 107a,b**)

Large, variable in form, with the body about as broad as it is long, the epitheca not large, with an obliquely set apical horn that has a broad base. Hypotheca with a broad posterior, and a somewhat concave left side. Antapical horns dissimilar, the right one shorter, arising near the girdle, with a bend tending to point in the same direction as the apical horn. The left antapical horn tends to form a more abrupt rounded curve, with both antapicals tending to blend in posterior profile, with a smooth to irregular pattern of curvature.

Oceanic-neritic. Widespread distribution. Found along the east coast, often in high concentrations, and sometimes producing summer blooms. This species is variable, producing a *Ceratium tripos* "complex" with intergrades often noted among several of the recognized varieties. Some investigators have collectively placed these forms under *C. tripos* (see *C. tripos* var. *atlanticum* and *C. tripos* var. *balticum*, Figs. 107 and 108).

Ceratium tripos var. *atlanticum* (Ostenfeld) Paulsen (Figure 108)

Epitheca with convex sides and apical horn only slightly obliquely set. Antapical horns generally similarly bent, diverging outward, but with right horn size variable, often reduced. Base of hypotheca flat, or slightly convex and continuous with antapical horns to present a broad, but not smooth, rounded outline. Chain formation common, with variable forms present in chain. Cell body width 60-90 µm.

Oceanic-neritic. Widespread along the east coast.

Ceratium tripos var. *balticum* Schütt (Figure 107c,d)

Apical horn straight, and being slightly oblique or in a plane that tends to be more perpendicular to the girdle; hypothecal posterior tends to be rounded obliquely; the antapical horns and hypotheca tending to form a broad curve; with this posterior outline often irregular. Antapical horns differ in length, the left being larger, thicker at the base, bent divergent to the apical horn. The right horn has a more defined bend, more parallel to apical horn. Cell body width 60-80 μm.

Oceanic-neritic. Common for the northeastern coastal waters.

Ceratium vultur Cleve (Figure 106)

A common chain forming species, variable in form; the first cell having a long straight or slightly bent horn; posterior cells have very short apical horn, bent at the base; apical horns with lists. Epitheca triangular and broad based; hypotheca also triangular, the left antapical horn directed first posteriorly, then bending sharply and curving in same direction of apical horn. The right antapical horn arises directly below the girdle and bends abruptly anteriorly. In some forms the antapicals diverge from apical horn. Lists common on each horn. Width of cell body 75-85 μm.

Oceanic. Tropical and sub-tropical species, frequently noted over the southeastern shelf.

Dinophysis acuminata Claparede et Lachmann (Figure 109)

Cell oval in lateral view, small, slightly convex epitheca, but variable, with hypotheca having a rounded, often a "rough" posterior due to one or more very small protuberances; both girdle lists small with or without spines, with left sulcal list narrow, supported by three main ribs and extending slightly more than half the body length. The theca has numerous poroids. Length 40-50 μm, width 20-38 μm.

Neritic. Wide distribution along the east coast.

Dinophysis acuta Ehrenberg (Figure 110)

Cell oval or obovoid, laterally compressed; being wider beyond the middle with a blunt point posteriorly, and off-center; epitheca slightly rounded, both girdle lists may or may not be ribbed, but are short, and funnel shaped; a left sulcal list, supported by spines, extends about 2/3 of the hypotheca. Antapex tends to be obliquely conical. Theca with numerous small poroids. Variations in shape common. Length 54-94 μm.

Oceanic-neritic. Wide distribution, common.

Dinophysis caudata Saville-Kent (Figure 111)

Elongated, irregularly shaped cell, variable, with a long hypotheca forming a finger-shaped, tapering, extension. The large left sulcal list supported by spines, extends along one side of the epitheca, the other side often has a small fin. Length 72-110 μm.

Oceanic-neritic. Temperate and warm water species, common along southeastern coast.

Dinophysis fortii Pavillard (Figure 112)

Cell ovoid in lateral view, variable, about 1½ times longer than wide, cell is widest below its middle and broadly, evenly rounded posteriorly; the epitheca flat to convex, with funnel-shaped anterior girdle list twice as wide as girdle; the left sulcal list has no prominent lobes, is about 0.6 as long as the cell. Length 50-75 μm.

Neritic. Warm water species, frequently noted along southeastern coast and in the Gulf Stream.

Dinophysis hastata Stein (Figure 113)

Cell ovoid, although broadest just below the middle. Epitheca small, with distinct funnel-shaped anterior list 1.5-2.5 times as wide as girdle; hypotheca with a sulcal list 0.5 to 0.75 body length, usually supported by ribs of which the most posterior is longest and slightly oblique. A winged spine is located posteriorly. This antapical spine and a posterior part of sulcal list may be absent in some fission specimens (see Taylor, 1976).

Neritic. Warm water species noted along the southeastern coast and in the Gulf Stream.

Dinophysis norvegica Claparede et Lachmann (Figure 114)

Cells obovoid with the hypotheca forming a bluntly pointed posterior. Hypotheca widest near the middle, with a left sulcal list supported by spines and extending slightly more than ½ body length. Numerous small thecal pores present. Often confused with *D. acuta*. Length 55-65 μm.

Neritic. Wide distribution. Frequently noted along the east coast.

Dinophysis ovum Schütt. (Figure 115)

Cell variable, irregularly and broadly ovoid, broadest below the middle, with the hypotheca having a broadly rounded posterior. Epitheca very small, slightly convex, with funnel-shaped anterior list, usually non-ribbed; sulcal list is broad, extending about one-half the body length. Poroids over theca. Length 45-65 μm.

Oceanic. More frequently noted in sub-tropical waters, but not in high concentrations.

Dinophysis punctata Jörgensen (Figure 116)

Cell ovoid, small, epitheca convex, with anterior girdle list wide and funnel-shaped, posterior list low. Hypotheca with rounded posterior. Sulcal list broad and supported by spines, extending about 2/3 body length. Theca with poroids. Length 25-40 μm.

Oceanic-neritic. Wide distribution, but not abundant.

Dinophysis schuettii Murray et Whitting (Figure 117)

Cell ovoid, oval, to spherical; epitheca small, with a high anterior list that is ribbed and funnel-shaped. The sulcal list is webbed, supported by strong spines that extend beyond membrane. Another long winged spine extends obliquely from the posterior end of the cell. Length 30-70 μm.

Neritic. Found in tropical waters in low concentrations.

Gonyaulax spinifera (Claparede et Lachmann) Diesing (Figure 121)

Cells somewhat ovoid, epitheca having convex sides, tapering to a short apical horn; hypotheca with convex sides, with or without two or more antapical spines. Girdle wide, oblique, descending and displaced at least twice its width. Length 24-50 μm, breadth 30-40 μm. Plate formula: 3', 0a, 6", 6"', 1p, 1"".

Neritic and estuarine. Widespread, frequently found over the shelf and within estuaries.

Gonyaulax tamarensis Lebour* (Figure 120)

Cells subspherical, slightly longer than wide, girdle only slightly displaced with a descending spiral. No apical horn, but with two very small antapical plate flanges that have been previously reported as small spines. Length 28-50 μm (most commonly 36-38 μm), breadth 28-48 μm. Plate formula: 4', 0a, 6", 6c, 7s+t, 6"', 1p, 1"" (Taylor, 1976).

Neritic near-shore species, associated with coastal and estuarine areas. Summer blooms common. *(*Protogonyaulax tamarensis* (Lebour) Taylor). There are several *Gonyaulax* species in a "tamarensis group" where routine identification is often difficult. This includes *Gonyaulax excavata* (Braarud) Balech which is responsible for toxic blooms in New England coastal areas and other sites along the northeastern coast, causing paralytic shellfish poisoning. See Taylor and Seliger (1979, Loeblich and Loeblich (1975).

Gymnodinium splendens Lebour* (Figure 122)

Cells large, unarmored, epicone broadly sub-hemispherical, apex bluntly pointed, sides angled, and straight or slightly concave. Hypocone trapezoidal, with two posterior lobes separated by a distinct depression. Sulcus does not enter epicone. Numerous chloroplasts. Length 50-75 μm, width 38-60 μm.

Estuarine-neritic. Wide distribution along the east coast. *(*Gymnodinium nelsoni* Martin). Campbell (1973) considered the species represented in Fig. 122 as *G. nelsoni*, based on the random distribution and size of the chloroplasts; in contrast to a radiating pattern and more elongated and slender chloroplasts originally associated with *G. splendens*.

Gyrodinium spirale (Bergh) Kofoid et Swezy (Figure 123)

Cell spindle-shaped, with spiral like girdle, that is descending and strongly displaced, with a spiral sulcus extending from antapex to apex; body nearly circular in cross section being widest posteriorly, often with one side convex, the other concave. Surface striate. Cell shape variable. Length 100-200 μm.

Oceanic-neritic. Wide distribution, frequently noted along the east coast.

Heterocapsa triquetra (Ehrenberg) Stein* (Figure 124)

Cell elongated, variable, spindle-shaped, irregular margin, with the posterior hypotheca ending in a blunted oblique point. No apical spine. Girdle equatorial, descending, displaced ½ girdle width, with a short sulcus. Length 19-30 μm, width 13-20 μm.

Neritic and estuarine. Widely distributed, common near shore along the east coast, often in high concentrations in low salinity areas. *(*Protoperidinium triquetra* (Stein) Lebour; there is some question as to the validity of the *Heterocapsa triquetra* designation; plate formula: 4', 2a, 7", 5"', 2"", Campbell, 1973).

Katodinium rotundatum (Lohmann) Loeblich III* (Figure 125)

Cells have arrowhead-shape, epicone conical with straight to slightly convex sides, hypocone narrower than the epicone, with a rounded posterior. Girdle wide. Sulcus not apparent. Length 7-18 μm, width 6-12 μm. *(*Amphidinium rotundatum* Lohmann).

Neritic-estuarine. Wide distribution along the east coast. Common, occasionally in high concentrations.

Ornithocercus magnificus Stein (Figure 126)

Cell subcircular in lateral outline; girdle list large, distinct funnel-shaped and both ribbed; right sulcal list small, left sulcal list is well-developed, extending to the dorsal side of the cell, with three distinct lobes. Length 40-120 μm.

Oceanic. Warm water species occasionally found over the southeastern shelf and occasionally in the Gulf Stream. Widely distributed in tropical and sub-tropical waters.

Oxytoxum milneri Murray et Whitting* (Figure 127)

Cell spingle-shaped, epitheca broad, tapering into a long asymmetrical process; hypotheca cone-shaped, long, with antapical end pointed. Theca areolate. Length 125-135 μm.

Oceanic-neritic. Warm water form, commonly found over the southeastern shelf and in the Gulf Stream. *(*O. subulatum* Kofoid)

Oxytoxum scolopax Stein (Figure 128)

Cell lanceolate, with epitheca bulbous, or pyriform, with a thin apical spine. Hypotheca long, conical, ending in an antapical spine that sometimes has a swelling at its base. Length 70-120 μm.

Oceanic-neritic. Warm water speices, found over the southeastern shelf and in the Gulf Stream.

Prorocentrum aporum (Schiller) Dodge* (Figure 129)

Cell oval, laterally constricted, without pores, having two chloroplasts. Length 30-34 μm, width 21-28 μm.

Oceanic-neritic. Wide distribution, but mainly in low concentrations. *(*Exuviella apora* Schiller)

Prorocentrum balticum (Lohmann) Loeblich III* (Figure 130)

Cell round to slightly oval, variable, but somewhat round in side view. There are very small apical projections beside the flagellar pores, with minute spines, detectable with electron microscopy, on the valves. Length 9-10 μm, width 7-20 μm.

Neritic. Wide distribution, often found in high concentrations. *(*Exuviella baltica* Lohamnn)

Prorocentrum gracile Schütt (Figure 131)

Cell lanceolate, asymmetrical, at least twice as long as broad.

Anterior end rounded and may or may not have a long spine; the posterior end of the cell is pointed. The valves have pores and depressions. Length 40-65 µm.

Oceanic-neritic. Wide distribution, may be confused with *Prorocentrum micans*. Frequently in northeastern shelf water, also noted in larger estuaries.

Prorocentrum micans Ehrenberg (Figure 132)

Cell may be slightly heart-shaped, having a broadly rounded anterior end, usually bearing a distinct short spine; the posterior end of the cell is slightly pointed. Cell is broadest around the middle, usually less than twice as long as broad and laterally compressed. However, the body shape and development of the apical spine is variable. The valves have pores and depressions. Length 35-70 µm, width 20-50 µm.

Neritic-estuarine. Widely distributed along the east coast, being very common within Bays and estuaries and over the entire shelf.

Prorocentrum minimum (Pavillard) Schiller* (Figure 133)

Cell oval to heart-shaped in valve view, with the anterior end rounded to flattened, having a slight depression. An anterior spine is small, often not visible. The posterior end is usually rounded, or slightly pointed. Variable shape. Using electron microscopy, minute spines indicated on the plates, which also have pores, mainly along the plate margin. Length 14-22 µm, width 10-15 µm.

Neritic-estuarine. Frequently found along the east coast, common within bay and estuarine systems often reaching bloom concentrations in spring. *(*Exuviella mariae-leboureae* Park & Ballantine: *E. minima* Pavillard; *Prorocentrum triangulatum* Martin)

Protoperidinium brevipes (Paulsen) Balech* (Figure 134)

Cell ovoid to rhombic in outline, epitheca conical to narrow-hemispherical; hypotheca truncated with antapical plates often with posterior spines. Girdle ascending, central and wide. No chloroplasts. Length 20-45 µm, width 20-35 µm. *(*Protoperidinium=Peridinium*)

Neritic-estuarine. Wide distribution along coast.

Protoperidinium claudicans (Paulsen) Balech (Figure 135)

Epitheca conical in ventral view, with sides convex, then tapering into an apical horn. Girdle descending, with lists. Hypotheca convex, forming two acute antapical horns. Spines absent. Length 50-100 µm.

Neritic. Widespread distribution, common, but not in high concentrations.

Protoperidinium conicum (Gran) Balech (Figure 136)

Cell in ventral view symmetrical, pentagonal; epitheca triangular with sides flat, or slightly concave, with first and seventh precingular plates triangularly shaped. Girdle straight, slightly descending. Hypotheca biconical, and variable in shape. Spines absent. Length 70-104 µm.

Neritic-estuarine. Wide distribution.

Protoperidinium depressum (Bailey) Balech (Figure 137)

Cell broad, flattened obliquely dorsiventrally, axis oblique, epitheca convex, then constricting slightly to form large apical horn; hypotheca extended, with two antapical horns diverging slightly. Girdle slightly descending. Considerable variation in shape, antapical horn development, and girdle displacement; especially between cold and warm water forms. Length 100-200 µm, width 75-150 µm.

Neritic-oceanic. Widely distributed. Common along the east coast.

Protoperidinium leonis (Pavillard) Balech (Figure 139)

Rhomboid in ventral view, with both epithecal and hypothecal margins straight, epitheca cone-shaped, hypotheca with a depression between two antapical horns. Girdle narrow and may be slightly descending. Differs from *P. conicum* by quadrangular shape, instead of triangular, of the first and seventh precingular plates. Cell diameter 65-95 µm, length 70-80 µm.

Oceanic. Wide distribution over the continental shelf.

Protoperidinium oceanicum (Van Höffen) Balech (Figure 140)

Cell elongated, dorsiventrally flattened; epitheca conical, concave; tapering to the apical horns; girdle displaced about two cingular widths, with a descending spiral; apical and antapical horns elongated and oblique. Longitudinal axis obliquely displaced. Shape and size variable. Length 150-250 µm. *P. oblongum* (Aurivillius) Parke et Dodge (See Figure 145) is considered by some investigators as a separate species, due to its difference in size and shape of the apical and antapical horns, and smaller size (length 120-170 µm), whereas others consider this another form within the *P. oceanicum* complex.

Neritic-oceanic. Found over the shelf. Common, but not in high concentrations.

Protoperidinium pallidum (Ostenfeld) Balech (Figure 141)

Slightly rhomboid to pyriform in ventral view, cell generally dorsiventrally flattened; girdle slightly ascending, with numerous choroplasts; epitheca cone-shaped, with hypotheca slightly rounded, without horns, but having two antapical spines and a false spine arising from the extended sulcal margin on the left side. Size and shape variable. See *P. pellucidum*. Length 55-105 μm.

Neritic-oceanic. Common over the continental shelf; sometimes found within the larger bays.

Protoperidinium pellucidum (Bergh) Schütt (Figure 142)

Cell shape variable, pyriform to broadly oval, girdle ascending slightly; epitheca cone-shaped, with apical horn reduced in size; hypotheca without antapical horns, but with two antapical spines and a false spine on the left side from a posterior sulcal fin. Similar to *P. pallidum* but is smaller, lacking chloroplasts, and is circular in cross section. Variability in shape common; antapical spines may be longer and slender, with a slightly longer apical horn (See Figure 142d). Length 40-68 μm, width 35-70 μm.

Neritic-estuarine. Wide distribution. Common.

Protoperidinium pentagonum (Gran) Balech (Figure 143)

Cell pentagonal in ventral view asymmetrical with left side slightly smaller than right; epitheca cone-shaped, hypotheca trapezoidal with two antapical horns, slightly developed, each with a small spine separated by shallow hollow that is flat to irregular in outline. Girdle median, spiral descending, with lists; sulcus short. Length 75-100 μm.

Neritic-oceanic. Noted along the east coast.

Protoperidinium steinii (Jörgensen) Balech (Figure 144)

Cell shape round to pyriform. Epitheca tapering to a long apical horn; hypotheca hemi-spherical, bearing two long antapical spines, each broadly winged. Girdle has slight ascending spiral, with lists. Length 39-88 μm.

Oceanic-neritic. Wide distribution, reported from both warm and cold waters.

Ptychodiscus brevis (Davis) Steidinger* (Figure 118)

Cell non-armored, slightly wider than it is long, epicone broad, with a slight apical process; hypocone posteriorly indented and bilobed. Girdle displaced 1-2 widths, descending; sulcus extends into epicone. Variable in size and shape. Width 20-40 μm.

Neritic-estuarine. Major toxic dinoflagellate along the Florida west coast and Gulf of Mexico; often associated with "Red Tide" events. *(*Gymnodinium breve* Davis) See Steidinger and Joyce, 1973.

Pyrocystis fusiformis Wyville-Thomson et Blackman (Figure 138)

Large vegetative cells (cysts), size variable; usually thin and fusiform, or with one end more rounded. These cells produce numerous small, motile thecate cells resembling *Gonyaulax*. There are broad differences in the size range given for forms of this species. In *P. fusiformis* f. *biconica*, the cell has a smaller length to width ratio, with the ends more rounded, and is generally less than 400 μm in length. Length 200-600 μm.

Oceanic. Associated with warm waters and the Gulf Stream.

HAPTOPHYCEAE (Prymnesiophyceae)

Electron microscopy is required to observe the fine details of coccolith structure for these species.

Calciosolenis murrayi Gran* (Figure 146)

Cylindrical body, tapered at ends, with spine-like extensions at both ends; cell covered with a diamond-shaped pattern of coccoliths, 2.5-3.5 x 1.0-1.3 μm. Cell body 59-80 μm in length, 4-5 μm wide.

Oceanic-neritic. Wide distribution, but usually found in low concentrations. *(*Calciosolenia sinuosa* Schlauder).

Cyclococcolithus leptopora (Murray et Blackman) Kamptner* (Figure 147)

Spherical cell; coccoliths broad, circular, convex and overlapping, each with a central depression. With electron microscopy the coccolith elements are seen in contact to each other, forming a curved, radial pattern; each coccolith having 18-31 elements. Coccolith diameter 6.3-7.2 μm, cell diameter 13-18 μm.

Oceanic-neritic. Wide distribution. Common over the continental shelf. *(*Cyclococcolithus leptoporus* (Murray & Blackman) Kamptner)

Emiliania huxleyi (Lohmann) Hay et Mohler* (Figure 148)

Cell spherical; with coccoliths oval and convex. Coccolith length 2.9-3.8 μm, width 2.0-3.1 μm. Cold and warm water forms have differences in number of elements and shield structure noticeable in electron microscopy.

Cell diameter 6-8 µm.

Oceanic-neritic. Wide distribution over the entire eastern continental shelf, often found in high concentrations. Due to their small size they are often overlooked. *(*Coccolithus huxleyi* (Lohmann) Kamptner, *Pontosphaera huxleyi* Lohmann)

Rhabdosphaera claviger Murray et Blackman* (Figure 149)

Cell spherical, with rod, or club-shaped coccoliths, having an oval basal plate; scattered over cell surface. Length of coccolith appendage 3.6-5.0 µm. Cell diameter 8-12 µm.

Oceanic. Wide distribution and common over eastern continental shelf, but usually not in high concentrations. *(Combined here with *Rhabdosphaera stylifer* Lohmann)

Syracosphaera pulchra Lohmann (Figure 150)

Cell oval to pyriform. Coccoliths elliptical, up to 4.5 µm long, coccoliths at anterior end different, possessing a vertically oriented extension. Cell length 9-26 µm.

Oceanic. Wide distribution and common over the eastern continental shelf, but usually in low concentrations.

CYANOPHYCEAE

Chroococcus limneticus Lemmermann (Figure 152)

Cells spherical, with adjacent faces of cells flattened after division, cells irregular dispersed in gelatinous colonies. Blue-green, red, violet. Cell diameter 6-12 µm. *(*Anacystis aeruginosa* Drouet et Dailey)

Estuarine-neritic. Wide distribution. Common along the east coast near estuaries and coastal wetlands.

Chroococcus turgidus (Kützing) Naegeli* (Figure 153)

Cells spherical, solitary, or in colonies of 2-4 cells, adjacent faces of cells flattened. Blue-green, violet, red, or olive. Cell diameter 12-50 µm.

Estuarine-neritic. Widespread distribution. Common at near shore locations along the east coast. *(*Anacystis dimidiata* (Kützing) Drouet et Daily)

Gomphosphaeria aponina Kützing (Figure 155)

Cells spherical, oval to pyriform in shape, forming closely packed colony of cells in matrix with sheath-like margin. Blue-green, olive, yellowish, violet, or red. Cell diameter 4-15 μm.

Estuarine-neritic. Widespread distribution along east coast. Common at near shore stations.

Johannesbaptistia pellucida (Dickie) Taylor et Drouet (Figure 156)

Cells discoid, forming colony of cells arranged in a single row, with the cells separated. Blue-green or olive. Diameter of filament up to 20 μm.

Neritic. Widespread distribution along the east coast; often found in larger estuaries.

Merismopedia punctata Meyen* (Figure 151)

Cells in flat, rectangular to irregular colonies; cells round, oval, or cylindrical, arranged in series of rows at right angles to each other. Blue-green, olive or violet. Cell diameter 4-10 μm.

Found in estuarine and coastal waters along the east coast. More common near shore. *(*Agmenellum thermale* (Kützing) Drouet et Daily)

Microcystis elebans Kützing* (Figure 154)

Cells elongate, ovoid to cylindrical, dividing in a plane perpendicular to the long axis, cells embedded in gelatinous matrix, cells 2-6 μm in diameter, usually 2-3 times as long as broad. Blue-green, olive-green, violet, or red.

Found in a variety of aquatic and marine habitats, having a wide distribution. More common near shore and by wetlands. *(*Coccochloris elebans* Drouet et Daily)

Nostoc commune Vaucher (Figure 157)

Trichomes of spherical to barrel-shaped cells constricted at the cross walls; cell size often variable within a trichome. Trichomes straight, curved, or spiraled. Heterocysts 2-12 μm in diameter. Sheath absent, or not clearly visible. Cell diameter 1.5-10 μm.

Estuarine-neritic. Wide distribution along the east coast. More frequently noted near the shore, often in vicinity of coastal wetlands and estuaries.

Oscillatoria erythraea (Ehrenberg) Geitler* (Figure 158)

Cells cylindrical, may be shorter, or longer than broad, protoplasm homogenous, or granulose, terminal cell cylindrical, bulbous-inflated, or truncate-conical, Trichomes 3-30 μm in diameter, straight, curved, or spiraled, with differences in cell width within a trichome common. Cell length 2-27 μm. Trichomes long and short, sheaths may or may not be present. Trichomes often interwoven in clusters. Blue-green, yellow-green, olive, brown, red, or violet.

Oceanic-neritic. Common over the eastern continental shelf, often reaching high concentrations. **Oscillatoria erythraea* represents a common marine species in which Drouet has placed several filamentous species of similar form and structure. These include *Trichodesmium erythraeum* Ehrenberg, *T. thiebautii* Gomont, *T. ehrengergii* Montangne, *Skujaella erythraea* de Toni, *Oscillatoria hildebrandtii* Geitler, and others. There are different viewpoints regarding the validity of these species as well as, placing them under *O. erythraea*.

Richelia intercellularis Schmidt (Figure 77)

Barrel-shaped cells, bluegreen, in short filaments with a larger spherical-shaped heterocyst at one, or both sides. Found as a frequent endosymbiont in *Rhizosolenia styliformis* and other *Rhizosolenia* spp. Cell size 5.5-10 μm, heterocysts 9-12 μm in width.

Oceanic-neritic. Widespread over the eastern continental shelf.

Spirulina subsalsa Oersted (Figure 159)

Cells form spirally twisted, cylindrical trichomes, with ends hemispherical, and with no cross walls. Diameter 0.4-4 μm. May be naked, or enclosed in mucus. Blue-green, olive, brown, red, or violet.

Estuarine-neritic. Widely distributed along the east coast. Most common near shore and in estuaries. Drouet recognized this as the only species in this genus, but with variations in form common.

Synechococcus spp. (Figure 160)

Cells spherical, cylindrical, ellipsoidal; 0.5-2.0 μm in size. Commonly found scattered within a water sample, and ubiquitous in marine and estuarine waters (Waterbury et al., 1979; Johnson and Sieburth, 1979). Distinction among the species within this genus would be impossible with light microscopy (see Stanier et al., 1971).

Ubiquitous across the shelf. Often present in very high concentrations within coastal estuaries and estuarine plumes. *(Includes *Anacystis marina* (Hansb.) Drouet et Daily)

CRYPTOPHYCEAE

Chroomonas amphioxeia (Conrad) Butcher* (Figure 161)

Cell ovoid, anterior end obliquely truncated, posterior end tapering. Length 10-19 μm, width 4-10 μm. Two equal flagella about ½ body length. *(*Rhodomonas amphioxei* Conrad).

Estuarine-neritic. More common to local estuaries, especially along southeastern coast. This species is representative of other members of this genus found along the east coast.

Cryptomonas pseudobaltica Butcher (Figure 162)

Cell 18-30 x 5-8 μm, slightly flattened, usually ovoid. The cell has convex sides, a sub-obtuse posterior, with an obliquely truncate and obtuse anterior. Two flagella of equal length.

Estuarine-neritic. This species is given as a representative type. Various *Cryptomonas* spp. are present along the east coast, often in high concentrations at mid-shelf locations. Cryptomonads are better preserved with Lugol's solution than formalin, which usually destroys or distorts many of these cells, giving inaccurate estimations of their presence.

PRASINOPHYCEAE

Pyramimonas micron Conrad et Kufferath (Figure 163)

Cell broadly ovoid, with convex sides, posteriorly rounded, with the anterior end having four broad lobes, and four flagella, which are longer than the cell. Cell length 4-8 μm, width 4-8 μm.

Estuarine-neritic. *P. micron* is representative for the genus, which has several species in estuaries along the east coast. See Campbell (1973).

Tetraselmis gracilis (Kylin) Butcher (Figure 164)

Cell has ellipsoid shape, compressed, with the posterior end rounded; anterior end with two lobes and four flagella. Cell length 8-12 μm, width 6-9 μm.

Estuarine-neritic. This is a common representative for the genus which usually has several species in the estuaries along the coast. See Campbell (1973).

CHLOROPHYCEAE

Chlorella marina Butcher (Figure 165)

Cells ovoid, 4-6 x 7-10 µm, cell walls thin and smooth. Chloroplast fills most of the cell as an irregular parietal plate; finely granular. Grass green.

Estuarine-neritic. Often in high concentrations at near shore locations; common within estuarine habitats and plumes.

Chlorella salina Butcher (Figure 166)

Cells spherical, 4-7 µm diameter, with thin, smooth cell walls and saucer-shaped chloroplast that mostly fills the cell. Grass green, finely granular; the pyrenoid is central and large.

Estuarine-neritic. Often in high concentrations at near shore locations and within estuarine plumes.

A "*Chlorella*" complex is frequently noted within the estuaries and bay systems along the east coast and over the shelf, and often in association with coccoid cyanobacteria. The Chlorella can usually be distinguished from this group with light microscopy by their distinct chloroplasts and more granular appearance. The relationship among *Chlorella vulgaris* Beijerinck, *C. salina* and *C. marina* is not clear and needs reevaluation. Butcher (1952) originally made the distinction between *C. salina* and *C. vulgaris* on the basis of a thinner cell wall and the marine habitat for *C. salina*. *C. vulgaris* is considered a cosmopolitan species, spherical to ellipsoidal in shape, with a size range 2-10 µm, and parietal cup-shaped, or girdle-shaped chloroplast (see Fott and Novakova, 1969).

Nannochloris atomus Butcher (Figure 167)

Cells spherical, pale green and finely granular; cell wall is thin and smooth. Chloroplast saucer-shaped, filling most of the cell. Cell diameter 2-3 µm. The distinction between *N. atomus* and the *Chlorella* group above is also not clear. See Sarokin and Carpenter (1982).

Estuarine-neritic. Wide distribution along the east coast and in estuarine habitats.

EUGLENOPHYCEAE

Euglena proxima Dangeard (Figure 168)

Cells without walls varying greatly in shape, fusiform to clavate and lanceolate, often blunt-obtuse tapering posteriorly. One long flagellum, readily visible, extending from gullet. Numerous discoid, grass green chloroplasts (25-40); stigma present, paramylum bodies numerous and ovoid; nucleus large, central, or slightly posterior. Length 60-90 μm, width 18-25 μm.

Estuarine. This is a representative species for the genus that has numerous species within estuarine and marine waters along the coast.

Eutreptia lanowii Steuer (Figure 169)

Cells elongated, cylindrical, varying in shape from compact to elongated; having two flagella of unequal length inserted at anterior end. Periplast smooth; scattered discoid paramylum bodies. Numerous green discoid chloroplasts. Similar in appearance to *Eutreptia viridis* Perty which has a striated periplast. Length 16-60 μm, width 4-10 μm.

Estuarine-neritic. Widespread distribution along the east coast.

SECTION 5

PHYTOPLANKTON ILLUSTRATIONS

Figure 1. *Actinoptychus senarius* Ehrenberg. a. Valve view, b. Girdle view. Reprinted with permission of the Ray Society (Lebour, 1930).

Figure 2. *Asterionella glacialis* Castracane. Girdle view. Reprinted with permission of the Ray Society (Lebour, 1930).

Figure 3. *Bacillaria paxillifer* (Muller) Hendey. Colony in girdle view. Reprinted with permission of Otto Koeltz Antiquariat (Hendey, 1964).

Figure 4. *Bacteriastrum delicatulum* Cleve. a. Colony in girdle view, b. Valve view. Reprinted with permission of Otto Koeltz Antiquariat (Hendey, 1964).

Figure 5. *Bellerochea malleus* (Brightwell) Van Heurck. a. Girdle view, b. Valve view. Reprinted with permission of Otto Koeltz Antiquariat (Hendey, 1964).

Figure 6. *Biddulphia alternans* (Bailey) Van Heurck. a. Girdle view, b. Valve view. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1939).

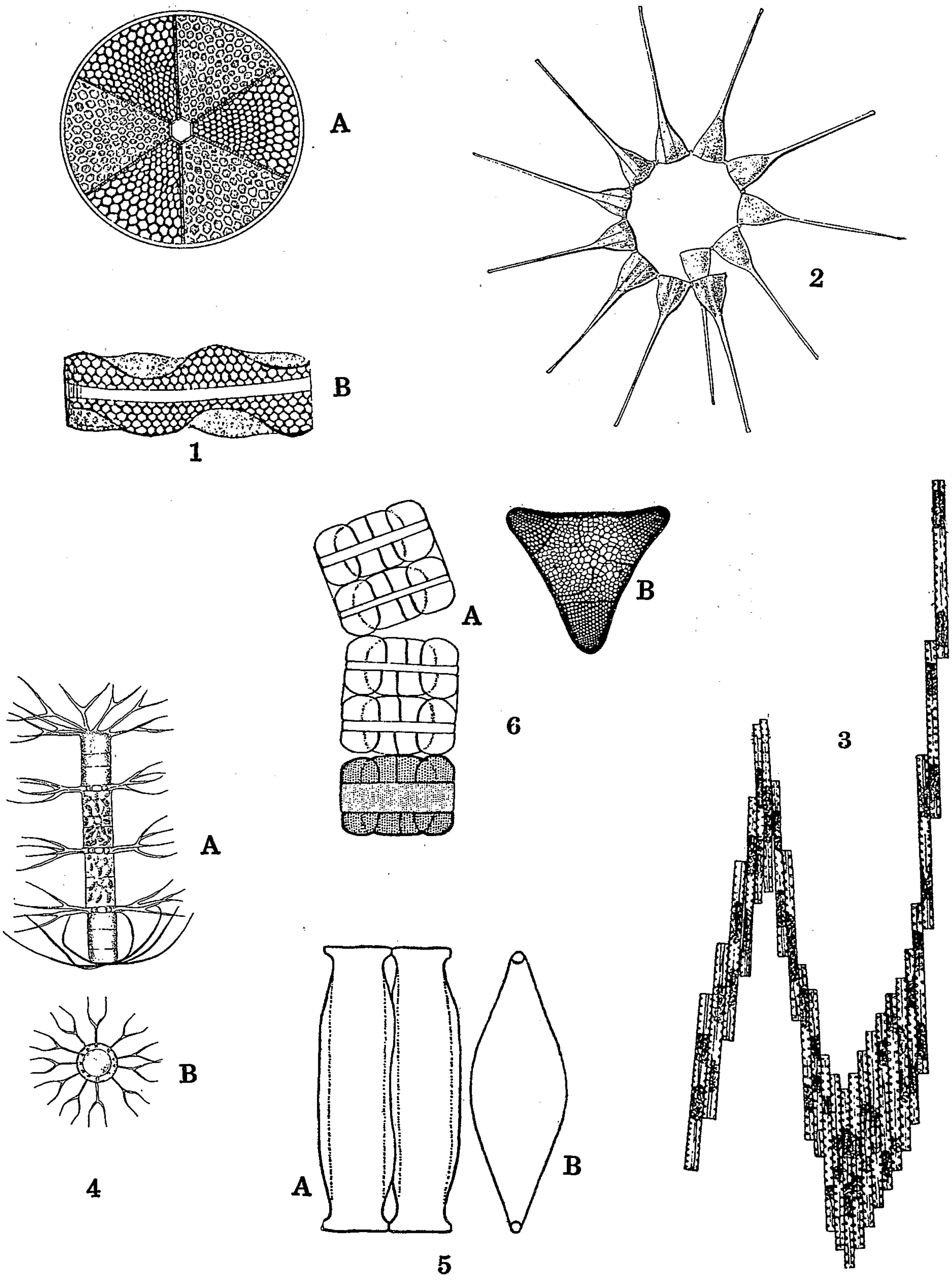
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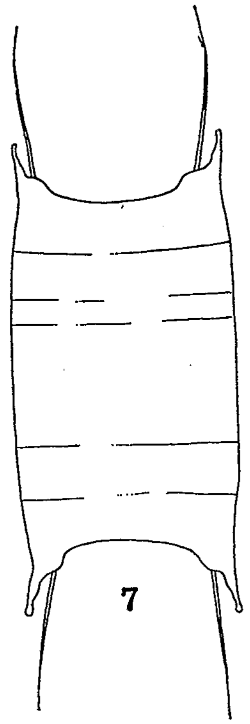
Figure 7. *Odontella mobiliensis* (Bailey) Grunow. Girdle view. Reprinted with permission of Otto Koeltz Antiquariat (Hendey, 1964).

Figure 8. *Odontella sinensis* (Greville) Grunow. Girdle view. Reprinted with permission of Otto Koeltz Antiquariat (Hendey, 1964).

Figure 9. *Chaetoceros lorenzianum* Grunow. Girdle view. Reprinted with permission of the Centre National de la Researche Scientifique (Trégouboff and Rose, 1957).

Figure 10. *Chaetoceros affine* Lauder. Showing characteristic types of chains in girdle view. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 11. *Chaetoceros atlanticum* Cleve. Entire chain and enlarged section in girdle view. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).



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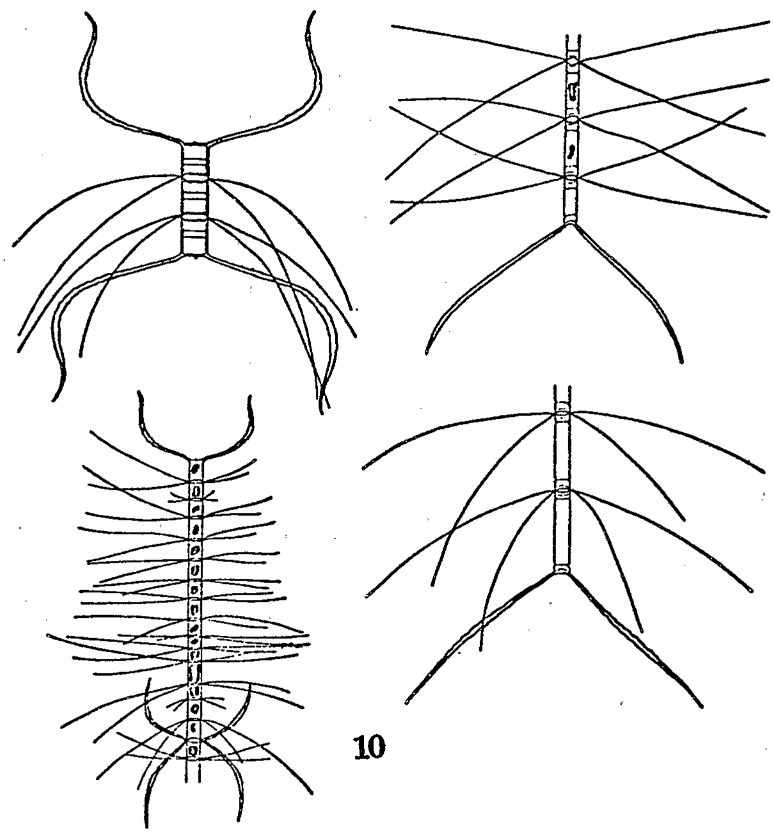

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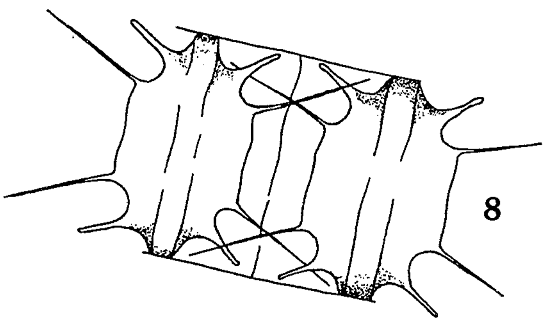

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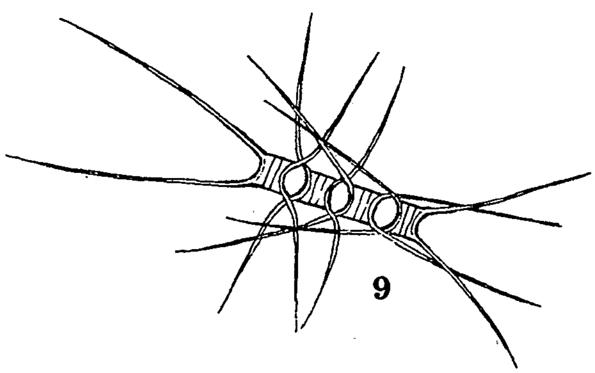

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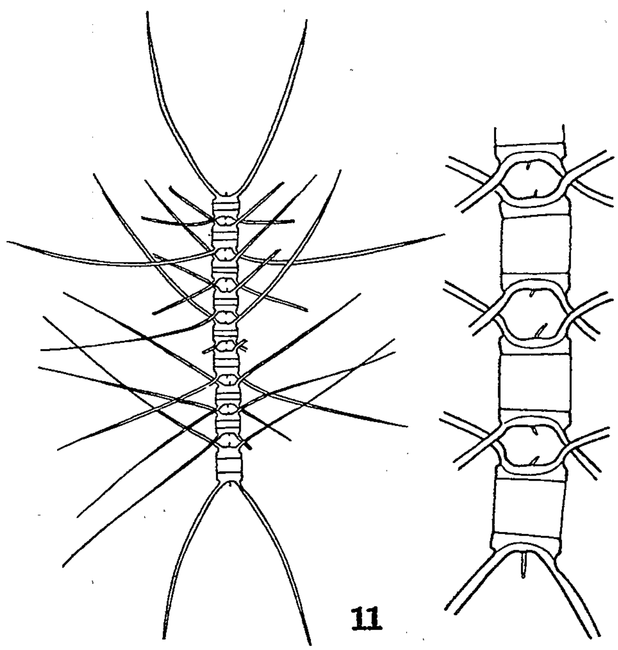

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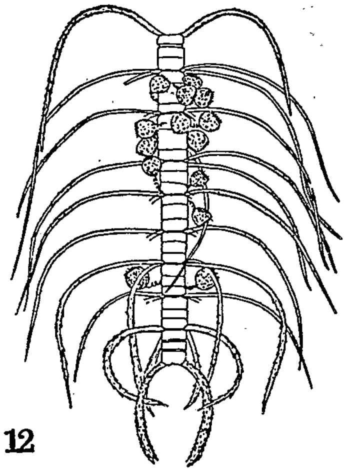
Figure 12. *Chaetoceros coarctatum* Lauder. Chain of cells in girdle view, with attached *Vorticella oceanica*. Reprinted with permission of University of California Press (Cupp, 1946).

Figure 13. *Chaetoceros concavicorne* Mangin. Different girdle views of cells. Reprinted with permission of University of California Press (Cupp, 1946).

Figure 14. *Chaetoceros debile* Cleve. Girdle view. Reprinted with permission of A. Asher and Company (Gran, 1908).

Figure 15. *Chaetoceros compressum* Lauder. Different girdle views of cells. Reprinted with permission of University of California Press (Cupp, 1946).

Figure 16. *Chaetoceros sociale* Lauder. Girdle view. Reprinted with permission of University of California Press (Cupp, 1946).



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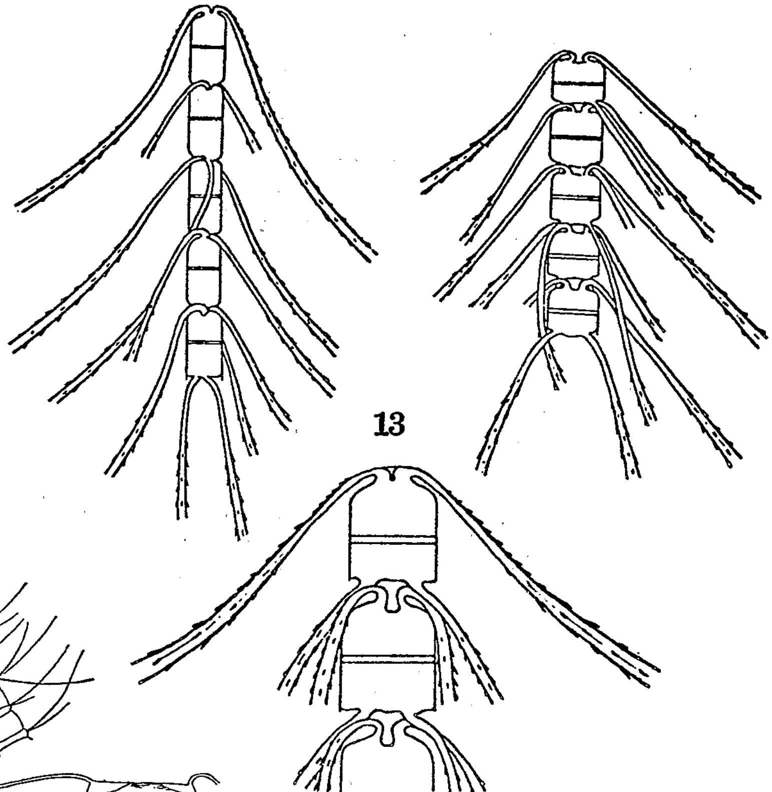

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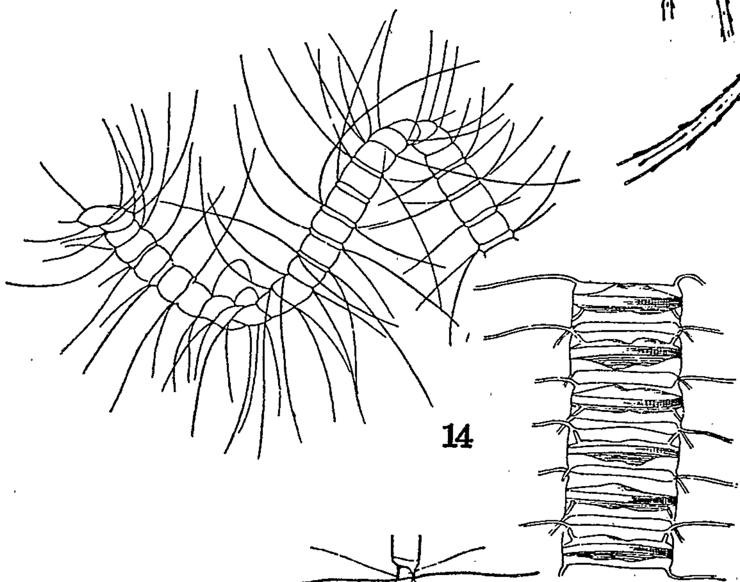

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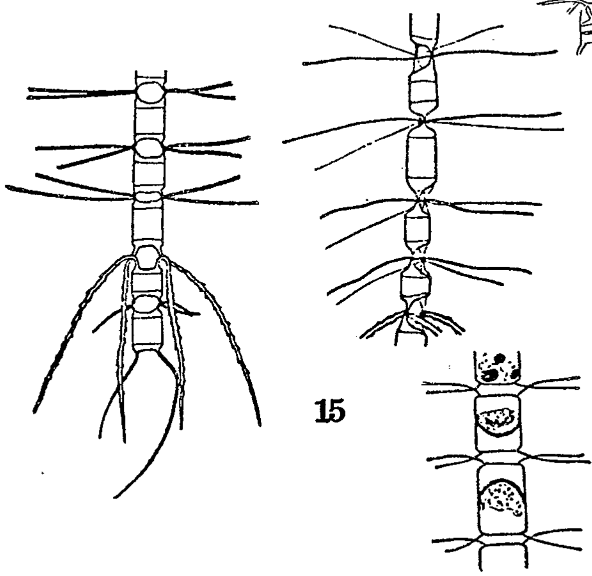

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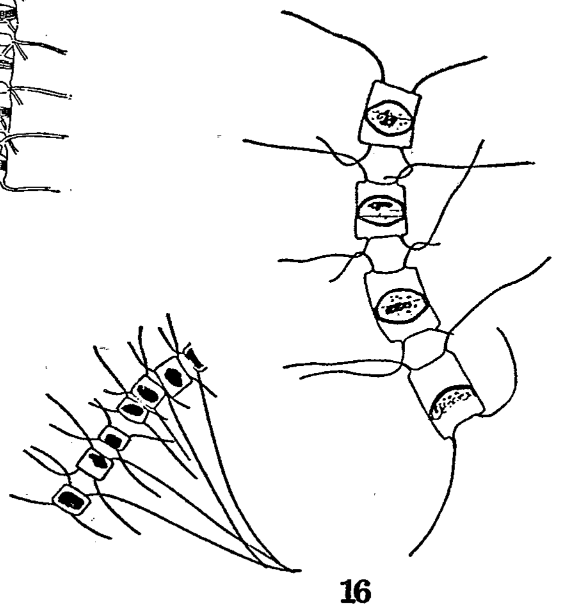

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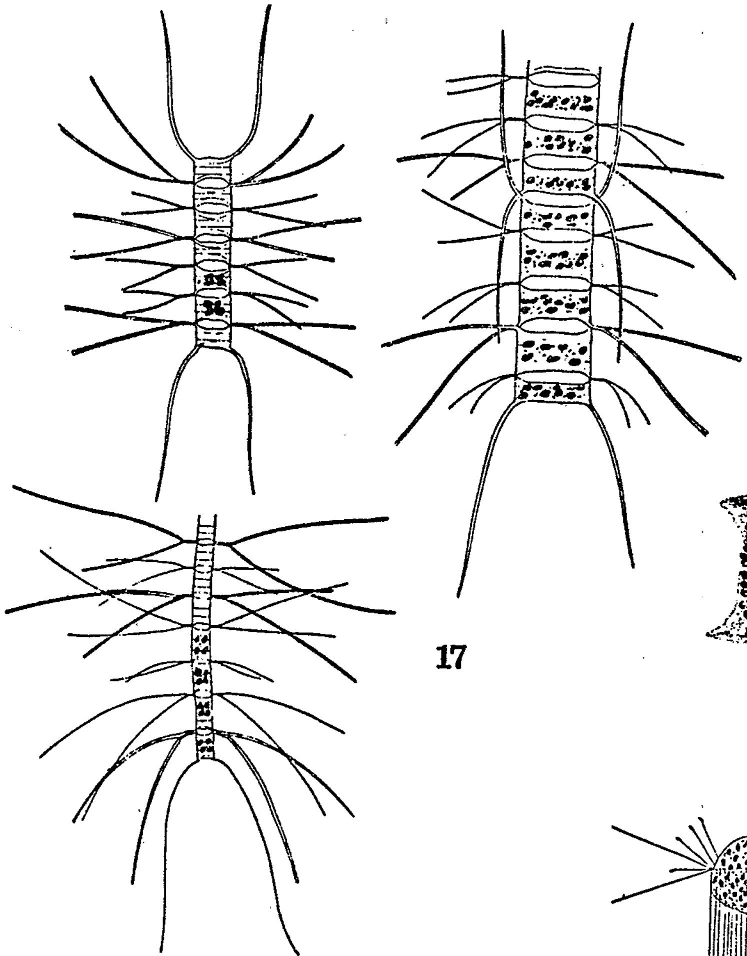
Figure 17. *Chaetoceros decipiens* Cleve. Several examples of cell chains showing variations in cell widths and apertures. Reprinted with permission of University of California Press (Cupp, 1946).

Figure 18. *Chaetoceros diversum* Cleve. Cells in girdle view. Reprinted with permission of University of California Press (Cupp, 1946).

Figure 19. *Climacodium frauenfeldianum* Grunow. Chain of cells in girdle view. Reprinted with permission of Otto Koeltz Antiquariat (Karsten, 1907).

Figure 20. *Cocconeis scutellum* Ehrenberg. Valve view. Reprinted with permission of Harper and Row Publishers, Inc. (Boyer, 1916).

Figure 21. *Corethron criophilum* Castracane. Several examples of dividing and mature cells. Reprinted with permission of University of California Press (Cubb, 1946).



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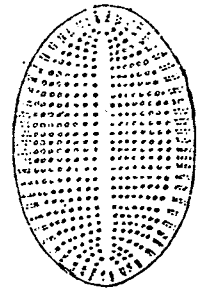

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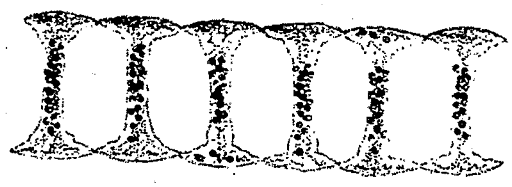

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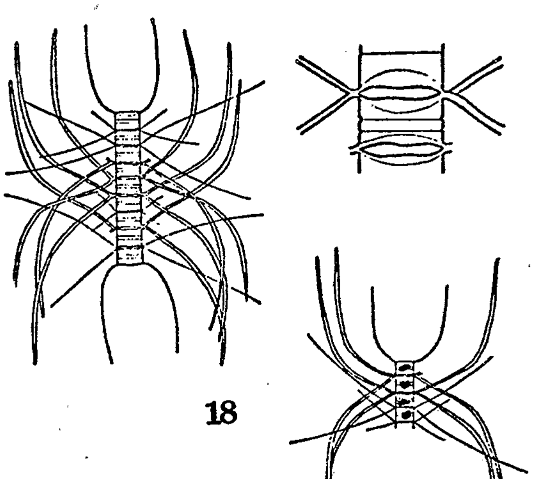

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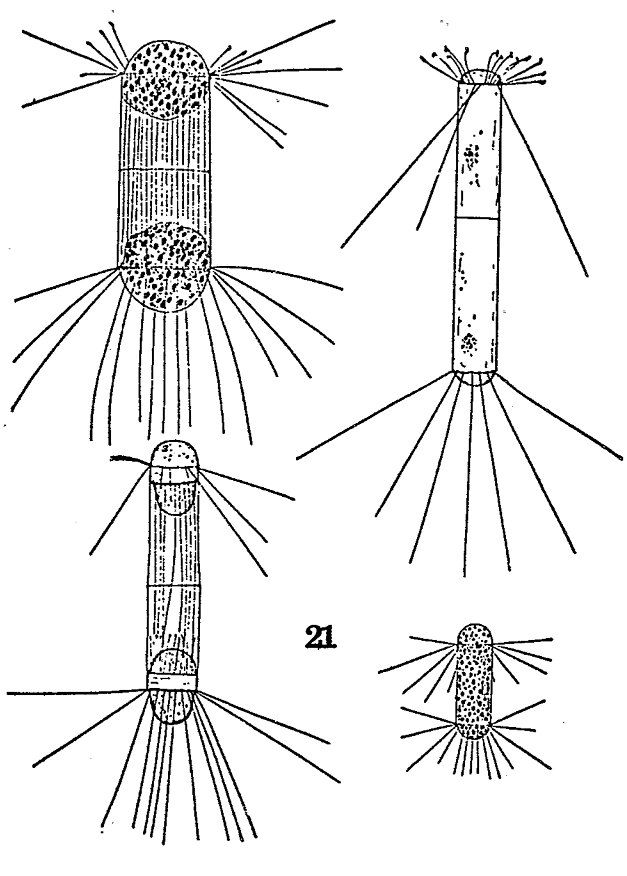

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Figure 22. *Coscinodiscus centralis* Ehrenberg. a. Girdle view. Reprinted with permission of the Ray Society (Lebour, 1930). b. Sections of valve view enlarged. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 23. *Coscinodiscus concinnus* W. Smith. a. Valve view, b. Valve view section enlarged, reprinted with permission of University of California Press (Cupp, 1946), and c. Girdle view, reprinted with permission of the Ray Society (Lebour, 1930).

Figure 24. *Coscinodiscus granii* Gough. a. Girdle view, b. Valve view, c. Center of valve showing rosette. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 25. *Coscinodiscus lineatus* Ehrenberg. Valve view and enlarged section. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 26. *Coscinodiscus marginatus* Ehrenberg. Valve view. Reprinted with permission of University of California Press (Cupp, 1946).

Figure 27. *Coscinodiscus nitidus* Gregory. Valve view. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 28. *Coscinodiscus oculus-iridis* Ehrenberg. a. Valve view, with the center enlarged to show rosette (b and c). Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

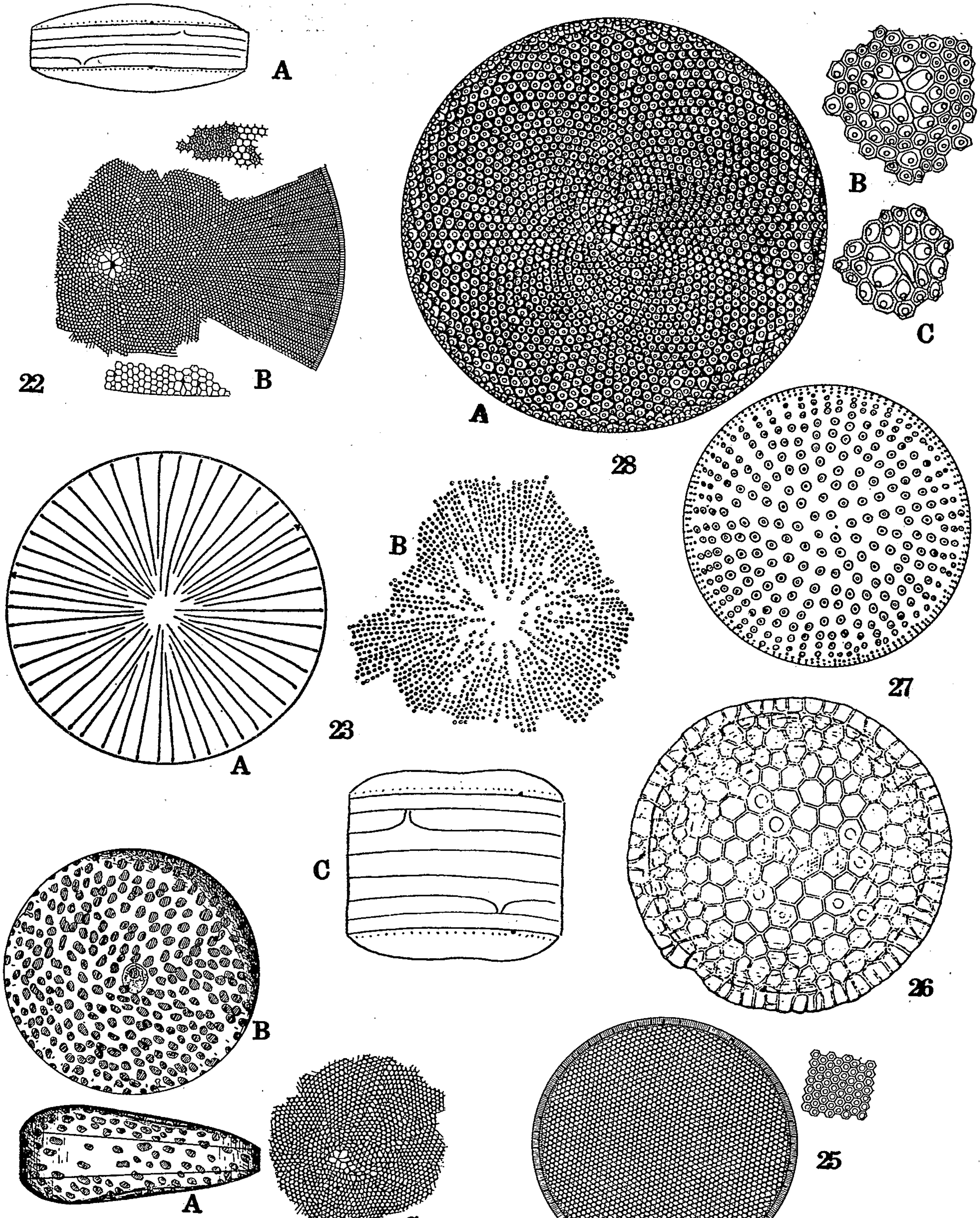
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Figure 29. *Coscinodiscus radiatus* Ehrenberg. a, b. Valve view, c. Girdle view. Reprinted with permission of A. Asher and Company (Gran, 1908).

Figure 30. *Coscinodiscus wailesii* Gran et Angst. a. Girdle view, b, c. Valve view sections. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 31. *Coscinosira polychorda* (Gran) Gran. Girdle view of cells in chain formation. Reprinted with permission of Otto Koeltz Antiquariat (Hendey, 1964).

Figure 32. *Cyclotella striata* (Kützing) Grunow. a. Girdle view, b. Valve view. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 33. *Cylindrotheca closterium* (Ehrenberg) Reiman et Lewin. Girdle view. Reprinted with permission of Otto Koeltz Antiquariat (Hendey, 1964).

Figure 34. *Cymatosira belgica* Grunow. Chain of cells in valve and girdle views. Reprinted with permission of A. Asher and Company (Peragallo, 1897).

Figure 35. *Detonula confervacea* (Cleve) Gran. Girdle view. Reprinted with permission of Otto Koeltz Antiquariat (Hendey, 1964).

Figure 36. *Cyclotella meneghiniana* Kützing. a. Girdle view of two cells, b. Valve view. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 37. *Ditylum brightwellii* (West) Grunow. Reprinted with permission of the Ray Society (Lebour, 1930).

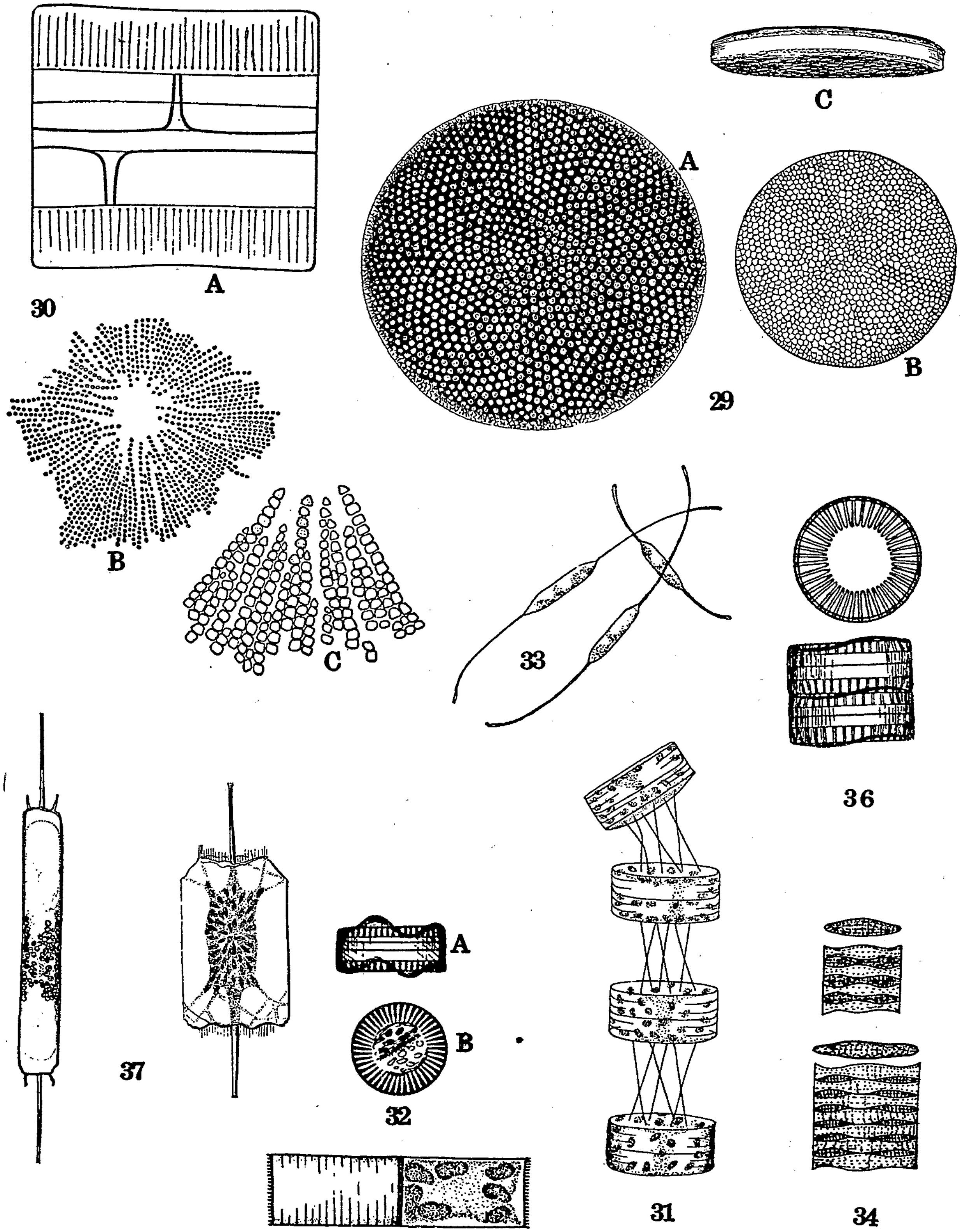
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Figure 38. *Eucampia zodiacus* Ehrenberg. a. Chain of cells in girdle view, b. Enlargement of two cells in chain. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 39. *Grammatophora marina* (Lyngbye) Kützing. a. Girdle view, b. Girdle view of dividing cell, c. Chain of cells. Reprinted with permission of University of California Press (Cupp, 1946).

Figure 40. *Guinardia flaccida* (Castracane) Peragallo. Girdle view. Reprinted with permission of the Ray Society (Lebour, 1930).

Figure 41. *Gyrosigma balticum* (Ehrenberg) Cleve. Valve view. Reprinted with permission of Harper and Row Publishers, Inc. (Boyer, 1916).

Figure 42. *Gyrosigma fasciola* (Ehrenberg) Cleve. Valve view. Reprinted with permission of Harper and Row Publishers, Inc. (Boyer, 1916).

Figure 43. *Hemiaulus hauckii* Grunow. a. Girdle view, b. Enlargement of cell processes. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 44. *Hemiaulus sinensis* Greville. a-c. Cells in girdle views. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 45. *Leptocylindrus danicus* Cleve. Girdle view. Reprinted with permission of the Ray Society (Lebour, 1930).

Figure 46. *Leptocylindrus minimus* Gran. Girdle view. Reprinted with permission of the Ray Society (Lebour, 1930).

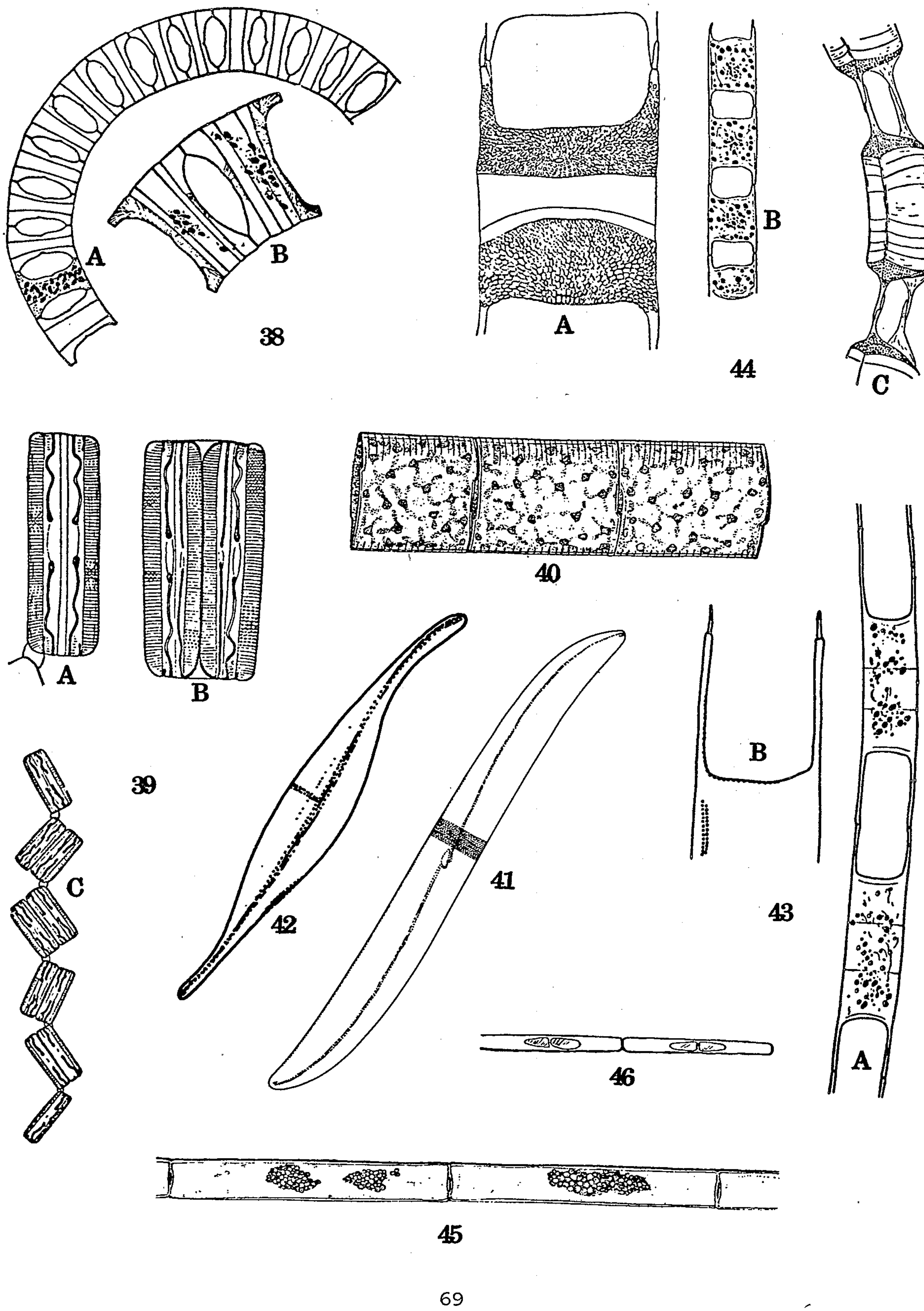
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Figure 47. *Lithodesmium undulatum* Ehrenberg. a. Chain of cells in girdle view, b. Valve view. Reprinted with permission of the Centre National de la Researche Scientifique (Trégouboff and Rose, 1957).

Figure 48. *Melosira distans* (Ehrenberg) Kützing. Examples of cells in girdle view. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 49. *Nitzschia delicatissima* Cleve. a. Girdle view, b. Valve view. Reprinted with permission of University of California Press (Cupp, 1946).

Figure 50. *Nitzschia longissima* (Brébisson) Ralfs. Reprinted with permission of University of California Press (Cupp, 1946).

Figure 51. *Nitzschia pungens* Grunow. a. Valve view, b. Girdle view, c. Chain of cells in girdle view. Reprinted with permission of University of California Press (Cupp, 1946).

Figure 52. *Nitzschia seriata* Cleve. Valve views. Reprinted with permission of University of California Press (Cupp, 1946).

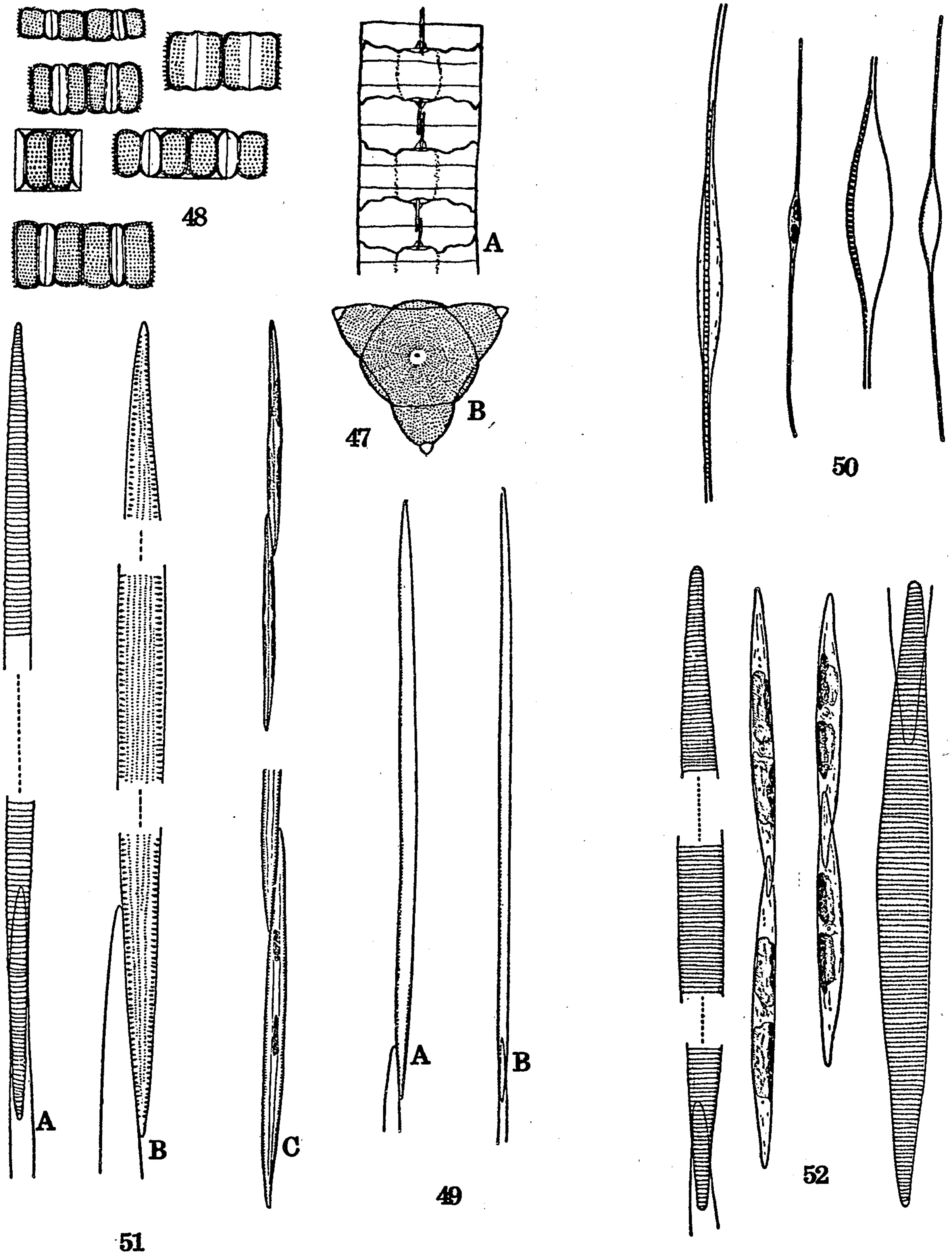
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Figure 53. *Melosira moniliformis* (Muller) Agardh. Girdle view of chain of cells. Reprinted with permission of Otto Koeltz Antiquariat (Hendey, 1964).

Figure 54. *Melosira nummuloides* (Dillwyn) Agardh. Girdle view of chain of cells. Reprinted with permission of Otto Koeltz Antiquariat (Hendey, 1964).

Figure 55. *Diploneis crabro* Ehrenberg. Valve view. Reprinted with permission of Harper and Row Publishers, Inc. (Boyer, 1916).

Figure 56. *Paralia sulcata* (Ehrenberg) Cleve. Chain of cells in girdle view. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 57. *Plagiogramma vanheurckii* Grunow. a. Valve view, b. Girdle view of cells. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 58. *Planktoniella sol* (Wallich) Schütt. Valve view. Reprinted with permission of Harper and Row Publishers, Inc. (Boyer, 1916).

Figure 59. *Pleurosigma aestuarii* (Brébisson) W. Smith. Valve view. Reprinted with permission of Harper and Row Publishers, Inc. (Boyer, 1916).

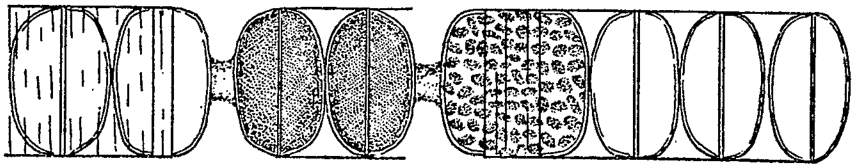
Figure 60. *Pleurosigma angulatum* (Quekett) W. Smith. Valve view. Reprinted with permission of Harper and Row Publishers, Inc. (Boyer, 1916).

Figure 61. *Pleurosigma obscurum* W. Smith. Valve view. Reprinted with permission of Harper and Row Publishers, Inc. (Boyer, 1916).

Figure 62. *Pleurosigma strigosum* W. Smith. Valve view. Reprinted with permission of Harper and Row Publishers, Inc. (Boyer, 1916).

Figure 63. *Rhaphoneis amphiceros* (Ehrenberg) Ehrenberg. Valve view. Reprinted with permission of A. Asher and Company (Peragallo, 1897) for Figure 63a and Harper and Row Publishers, Inc. for Figure 63b.

Figure 64. *Rhaphoneis suriella* (Ehrenberg) Grunow. Valve view. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).



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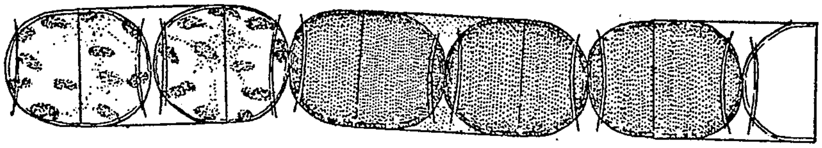

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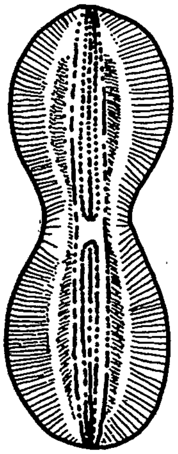

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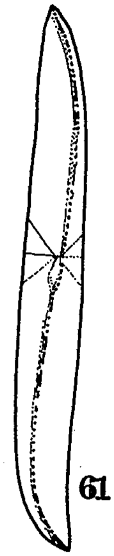

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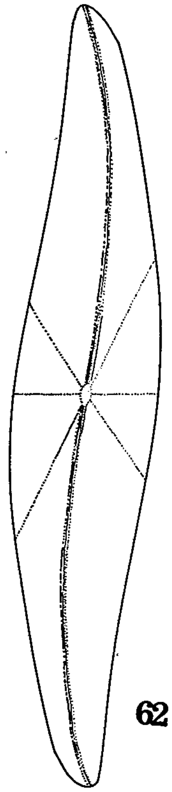

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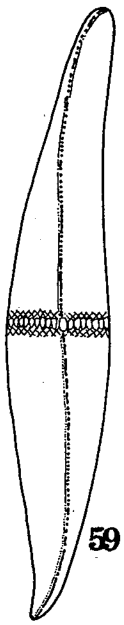

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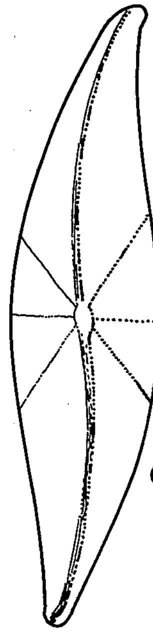

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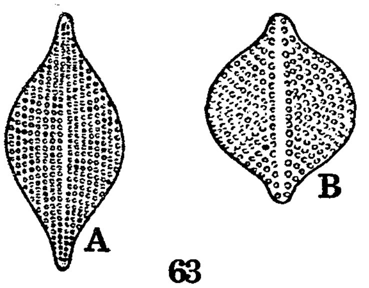

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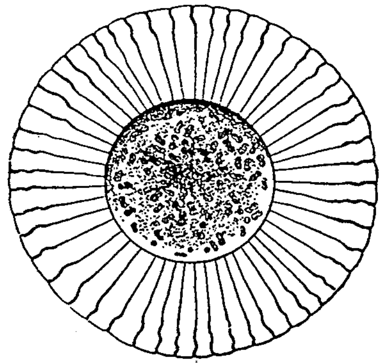

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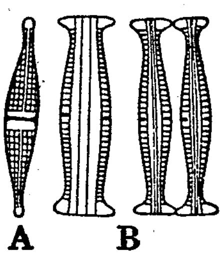

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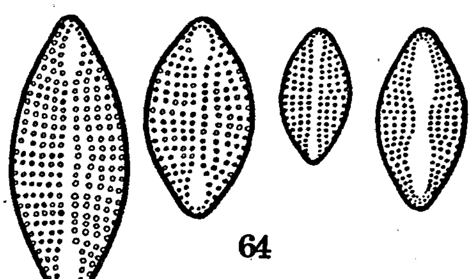

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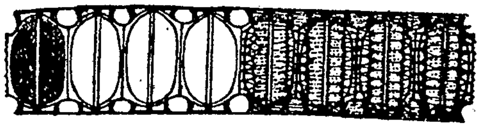

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Figure 65. *Rhizosolenia alata* Brightwell. Representative girdle view of different sized cells. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 66. *Rhizosolenia alata* f. *gracillima* (Cleve) Gran. Girdle view of cells. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 67. *Rhizosolenia alata* f. *indica* (Peragallo) Gran. Girdle views. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 68. *Rhizosolenia calcar-avis* Schultze. Girdle views. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 69. *Rhizosolenia castracanei* Peragallo. Girdle view. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 70. *Rhizosolenia delicatula* Cleve. Chain of cells in girdle view. Reprinted with permission of Otto Koeltz Antiquariat (Hendey, 1964).

Figure 71. *Rhizosolenia fragilissima* Bergon. Chain of cells in girdle view. Reprinted with permission of A. Asher and Company (Gran, 1908).

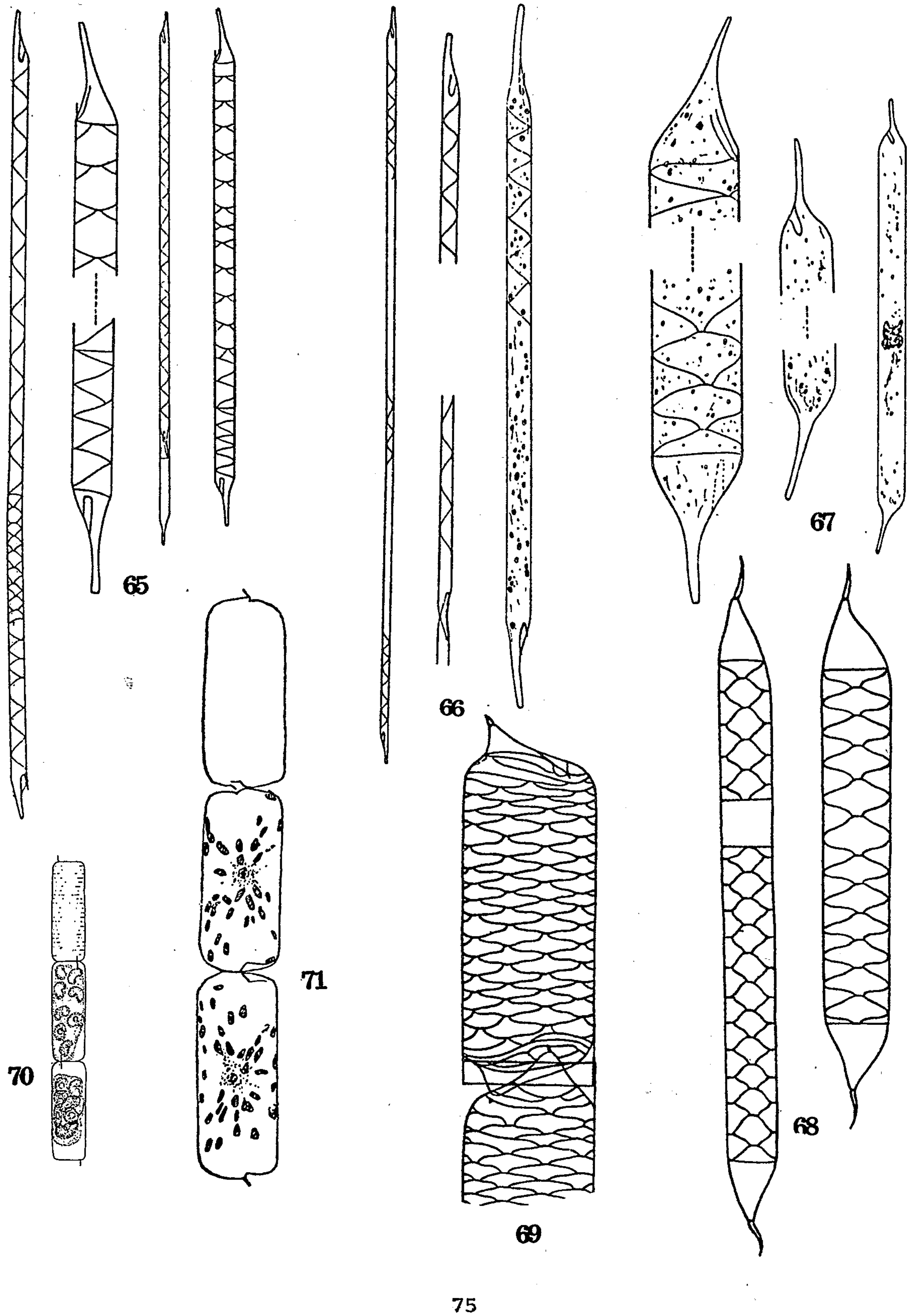
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Figure 72. *Rhizosolenia imbricata* Brightwell. Girdle views of sectioned cells. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 73. *Rhizosolenia robusta* Norman. Girdle view. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 74. *Rhizosolenia setigera* Brightwell. Girdle view. Reprinted with permission of the Ray Society (Lebour, 1930).

Figure 75. *Rhizosolenia shrubsolei* Cleve. Cell in various girdle views. Reprinted with permission of the Ray Society (Lebour, 1930).

Figure 76. *Rhizosolenia stolterfothii* Peragallo. a. Banding on a frustule, b. Chains of cells in girdle view. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 77. *Rhizosolenia styliformis* Brightwell. Different views of the cell in girdle view. Central cell contains endosymbiont *Richelia intercellularis* Schmidt. Reprinted with permission of University of California Press (Cupp, 1943).

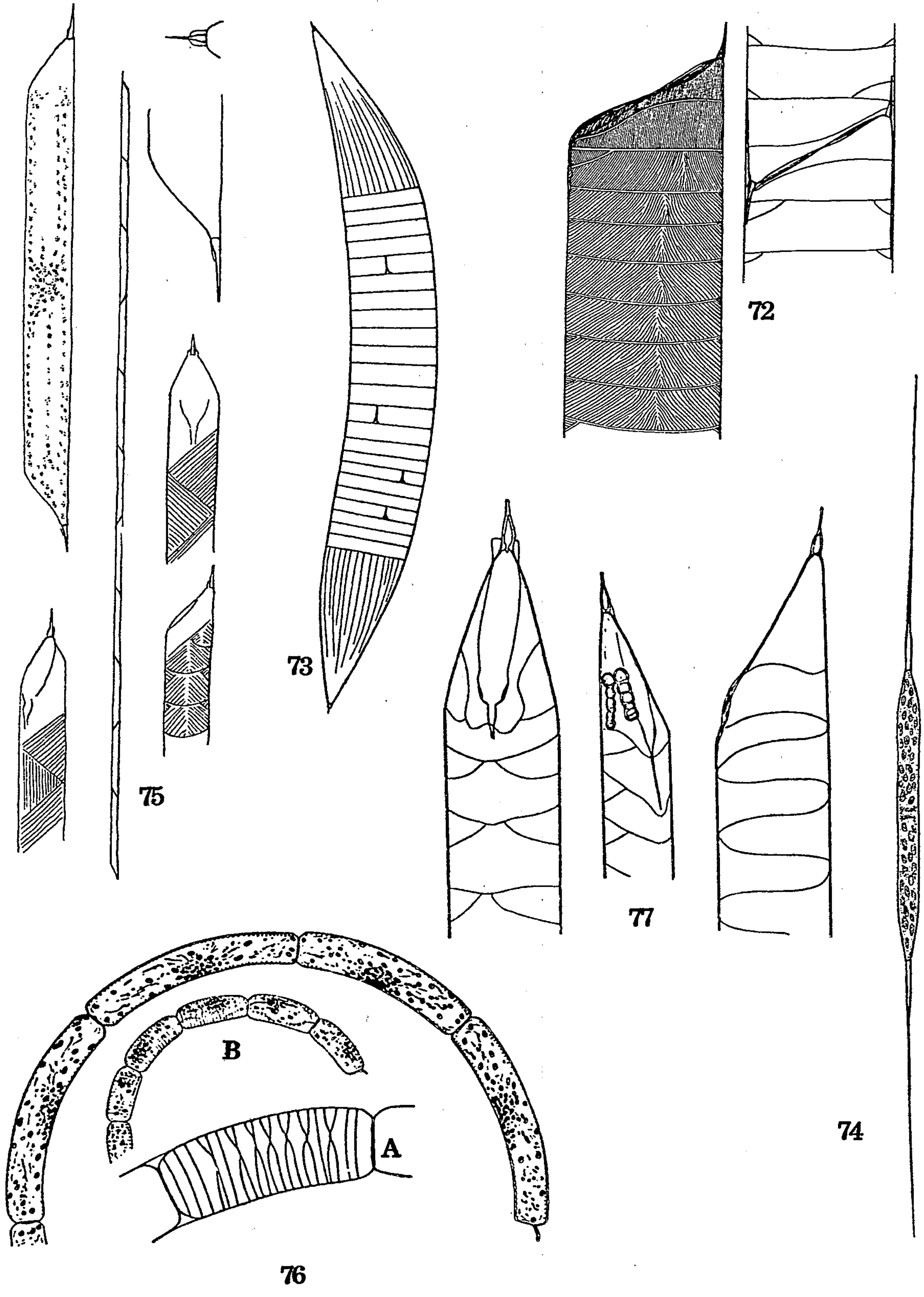
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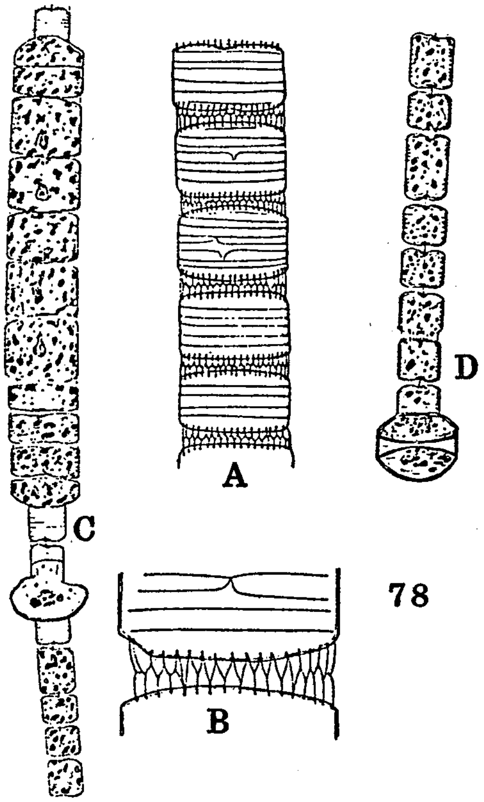
Figure 78. *Schroederella delicatula* (Peragallo) Pavillard. a. Chain of cells in girdle view, b. Ends of two cells showing zigzag pattern of connecting threads, c. Chain of cells containing both dividing auxospores and normal cells, d. Chain of cells with an auxospore. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 79. *Skeletonema costatum* (Greville) Cleve. Chains of different sized cells in girdle view. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 80. *Stephanopyxis palmeriana* (Greville) Grunow. a, b. Chainsof cells in girdle view, c. Resting spores. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 81. *Streptotheca tamesis* Shrubsole. Chains of cells in girdle view. Reprinted with permission of Otto Koeltz Antiquariat (Hendey, 1964).

Figure 82. *Thalassionema nitzschioides* Hustedt. Long (a) and short (b) forms of colonies in girdle view. Reprinted with permission of the Ray Society (Lebour, 1930).



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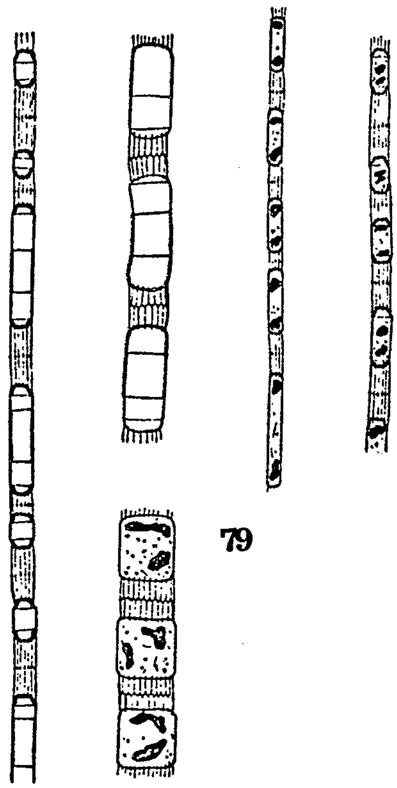

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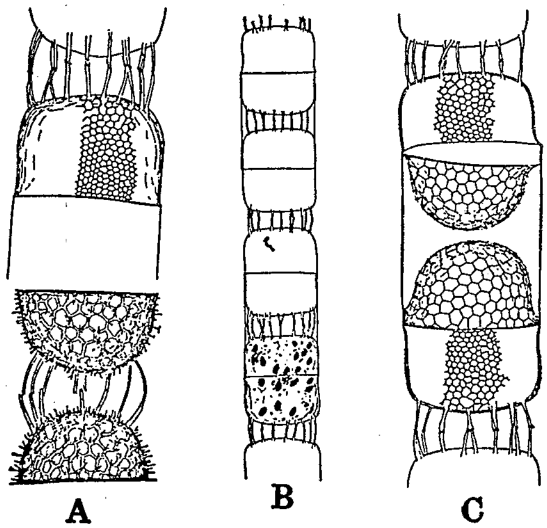

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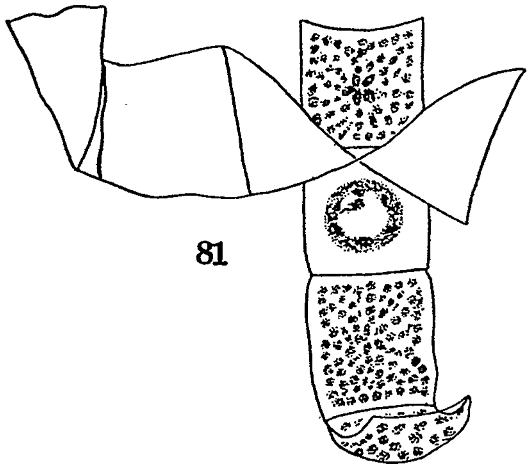

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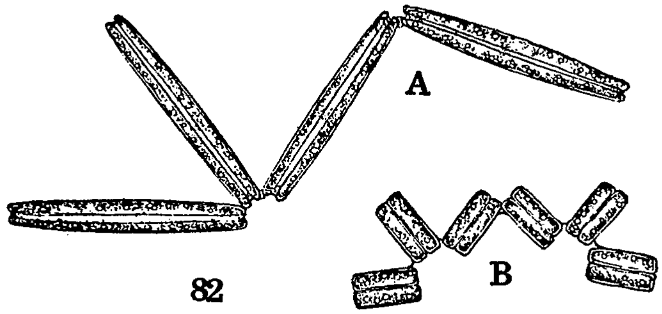

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Figure 83. *Thalassiosira eccentrica* (Ehrenberg) Cleve. a. Valve view, b. Girdle view. Reprinted with permission of the Ray Society (Lebour, 1930).

Figure 84. *Thalassiosira gravida* Cleve. Chain of cells in girdle view. Reprinted with permission of the Ray Society (Lebour, 1930).

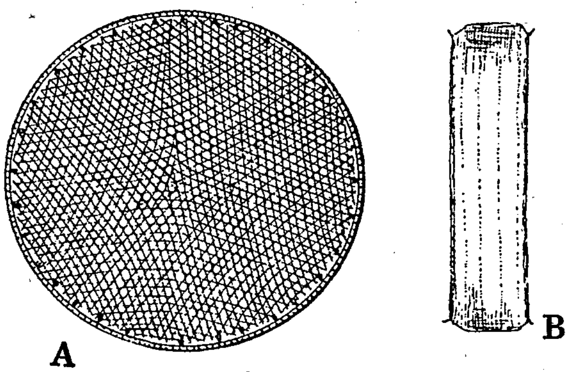
Figure 85. *Thalassiosira nordenskioldii* Cleve. a. Single cell in girdle view, b. Chain of cells in girdle view. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 86. *Thalassiosira rotula* Meunier. a. Valve view of cell, b. Chain of cells in girdle view. Reprinted with permission of Johnson Reprint Corporation (Hustedt, 1930).

Figure 87. *Thalassiosira subtilis* (Ostenfeld) Gran. a. Cells in valve view, b. Cell in girdle view. Reprinted with permission of the Ray Society (Lebour, 1930).

Figure 88. *Thalassiothrix frauenfeldii* Grunow. a. Cells in girdle view, b. Valve view, c. Colony of cells. Reprinted with permission of University of California Press (Cupp, 1943).

Figure 89. *Cerataulina pelagica* (Cleve) Hendey. Girdle views showing different perspectives. Reprinted with permission of University of California Press (Cupp, 1943).



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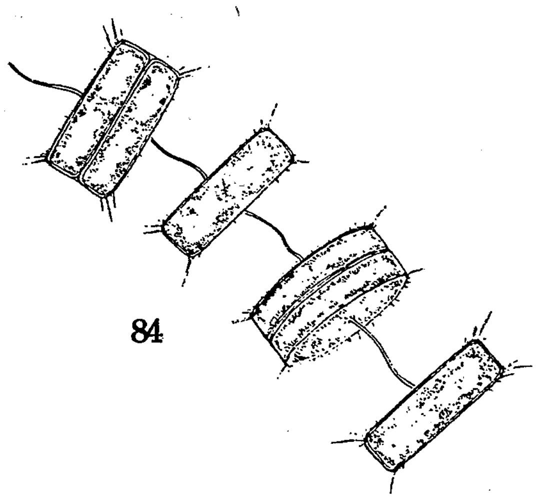

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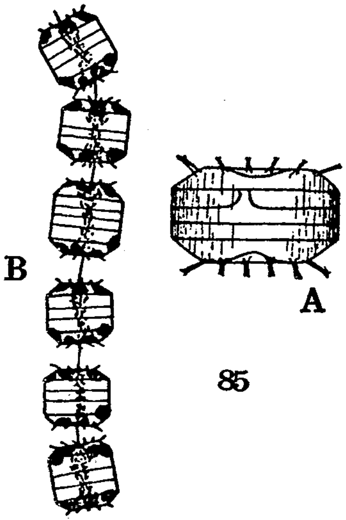

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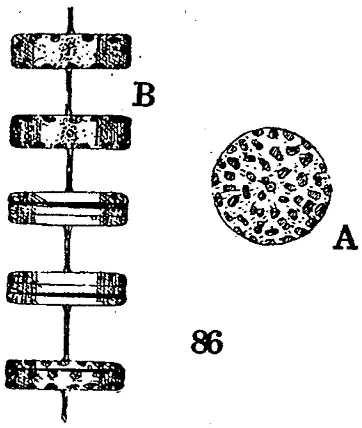

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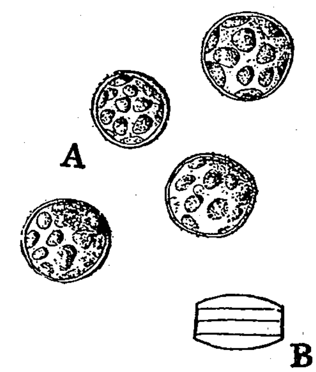

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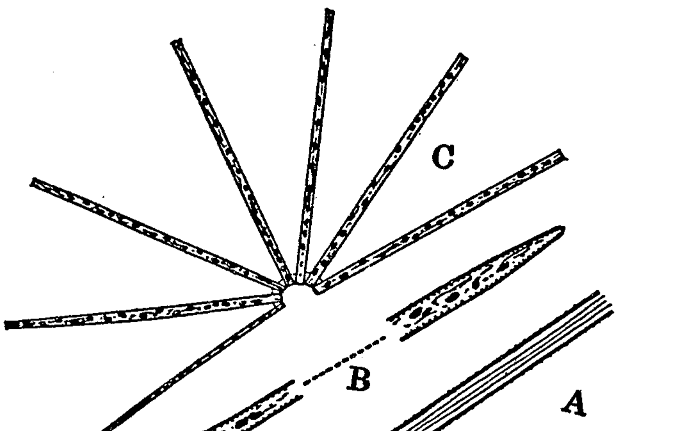

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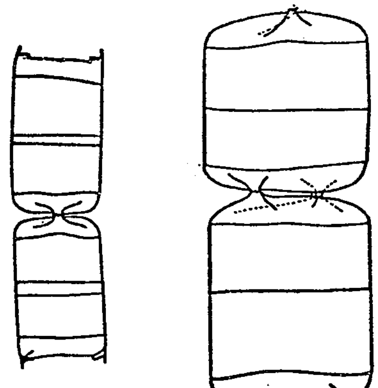

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Figure 90. *Dictyocha fibula* Ehrenberg. Skeletons. Reprinted with permission of Geological Society of America, Inc. (Loeblich, III et al., 1968).

Figure 91. *Distephanus speculum* (Ehrenberg) Haeckel. Skeleton. Reprinted with permission of Geological Society of America, Inc. (Loeblich, III et al., 1968).

Figure 92. *Ochromonas caroliniana* Campbell. Reprinted with permission of Peter H. Campbell (Campbell, 1973).

Figure 93. *Ceratium arcticum* (Ehrenberg) Cleve. Ventral view. Reprinted with permission of the Marine Biological Association of the U.K. (Lebour, 1925).

Figure 94. *Ceratium contortum* (Gourret) Cleve. Dorsal view. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937).

Figure 95. *Ceratium extensum* (Gourret) Cleve. Reprinted with permission of the Marine Biological Association of the U.K. (Lebour, 1925).

Figure 96. *Ceratium furca* (Ehrenberg) Claparede et Lachmann. Ventral view. Reprinted with permission of the Marine Biological Association of the U.K. (Lebour, 1925).

Figure 97. *Ceratium fusus* (Ehrenberg) Dujardin. Ventral view. Reprinted with permission of the Marine Biological Association of the U.K. (Lebour, 1925).

Figure 98. *Ceratium lineatum* (Ehrenberg) Cleve. Ventral view. Reprinted with permission of A. Asher and Company (Paulsen, 1908).

Figure 99. *Ceratium longipes* (Bailey) Gran. Ventral view. Reprinted with permission of the Marine Biological Association of the U.K. (Lebour, 1925).

Figure 100. *Ceratium minutum* Jörgensen. Ventral (a) and dorsal (b) views. Reprinted with permission of the Marine Biological Association of the U.K. (Lebour, 1925).

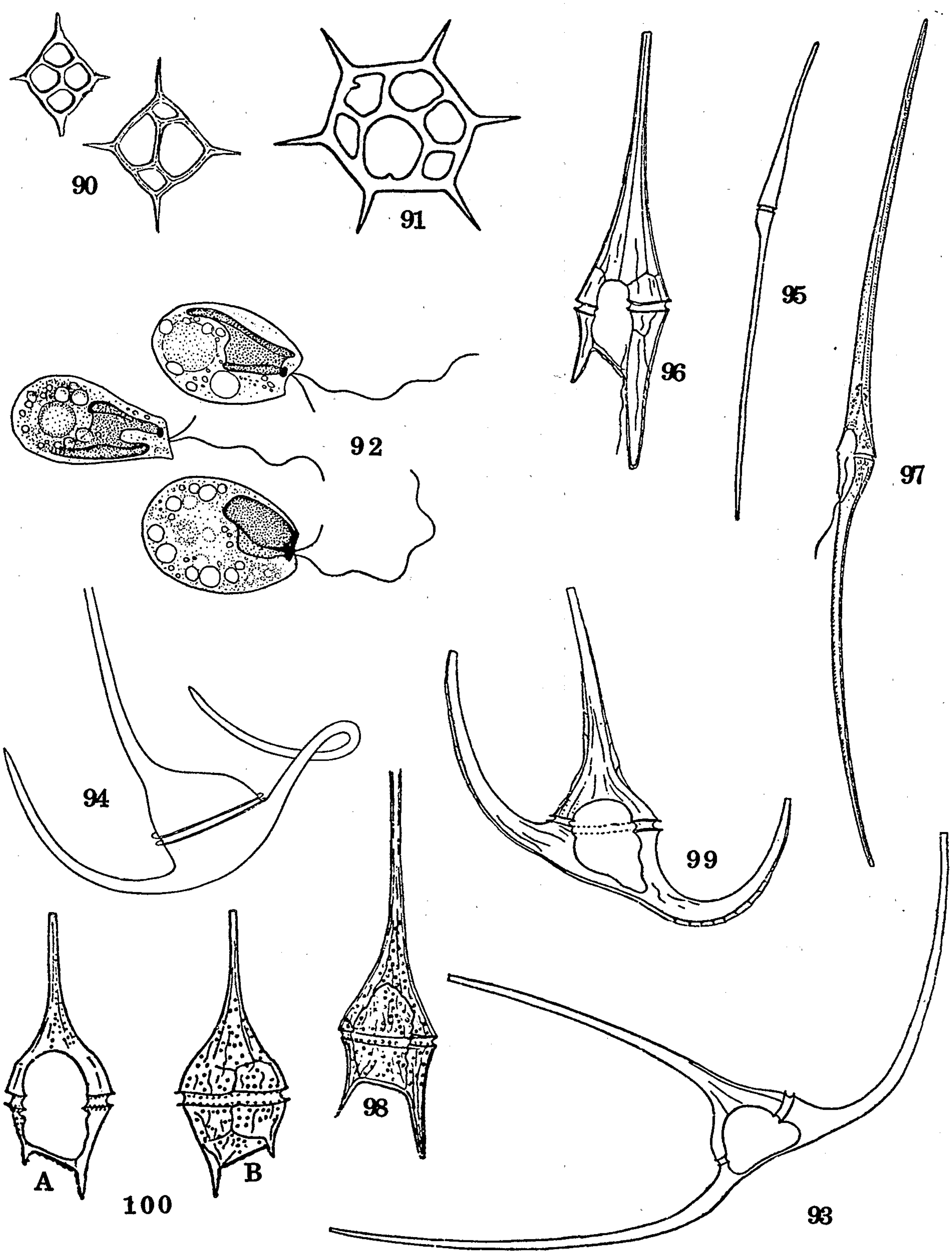
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Figure 101. *Ceratium carriense* Gourret. Different cell forms. a. Ventral view. Reprinted with permission of the Centre National de la Researche Scientifique (Trègouboff and Rose, 1957), and b. Dorsal view. Reprinted with permission of the Johnson Reprint Corporation (Schiller, 1937).

Figure 102. *Ceratium lunula* (Schimper) Jörgensen. Cells from a chain formation; first cell has longer apical horn (a), other cells in chain possess a shorter horn (b). Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937).

Figure 103. *Ceratium macroceros* (Ehrenberg) Van Höffen. Various cell types. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937).

Figure 104. *Ceratium massiliense* (Gourret) Karsten. Different cell types. a. Ventral view . Reprinted with permission of the Centre National de la Researche Scientifique (Trègouboff and Rose, 1957) and b. *C. massiliense* f. *protuberans* (Karsten) Jörg. Reprinted with permission of the Johnson Reprint Corporation (Schiller, 1937).

Figure 105. *Ceratium trichoceros* (Ehrenberg) Kofoid. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937).

Figure 106. *Ceratium vultur* Cleve. a. Two cells in series, b. Single cell. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937).

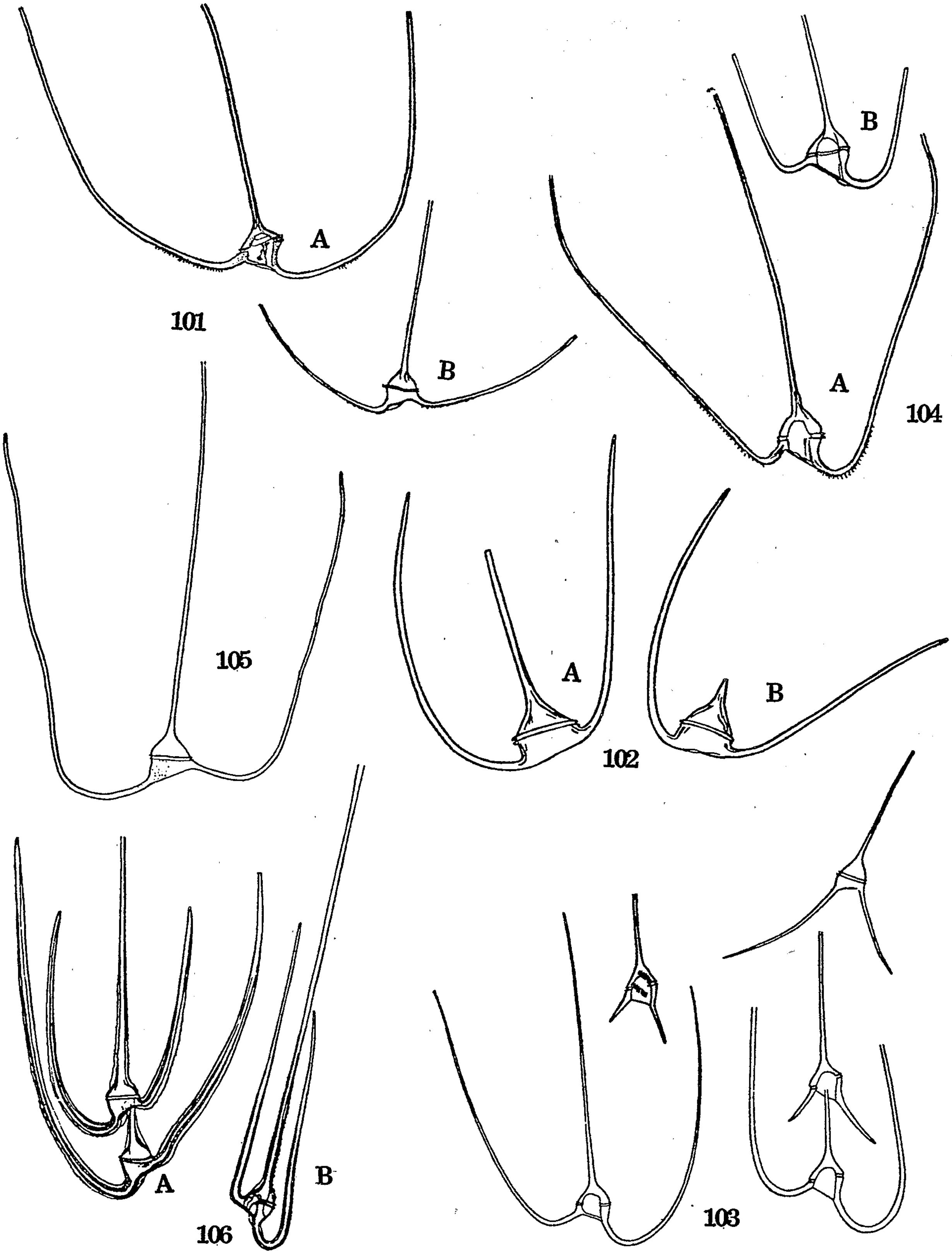
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Figure 107. *Ceratium tripos* (O. F. Muller) Nitzsch. Ventral (a) and dorsal (b) views. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937); and *Ceratium tripos* var. *balticum* Schütt. Ventral (c) and dorsal (d) views. Reprinted with permission of Marine Biological Association of the U.K. (Lebour, 1925).

Figure 108. *Ceratium tripos* var. *atlanticum* (Ostenfeld) Paulsen. Ventral view. Reprinted with permission of Marine Biological Association of the U.K. (Lebour, 1925).

Figure 109. *Dinophysis acuminata* Claparede et Lachmann. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1933).

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Figure 115. *Dinophysis ovum* Schütt. Reprinted with permission of Marine Biological Association of the U.K. (Lebour, 1925).

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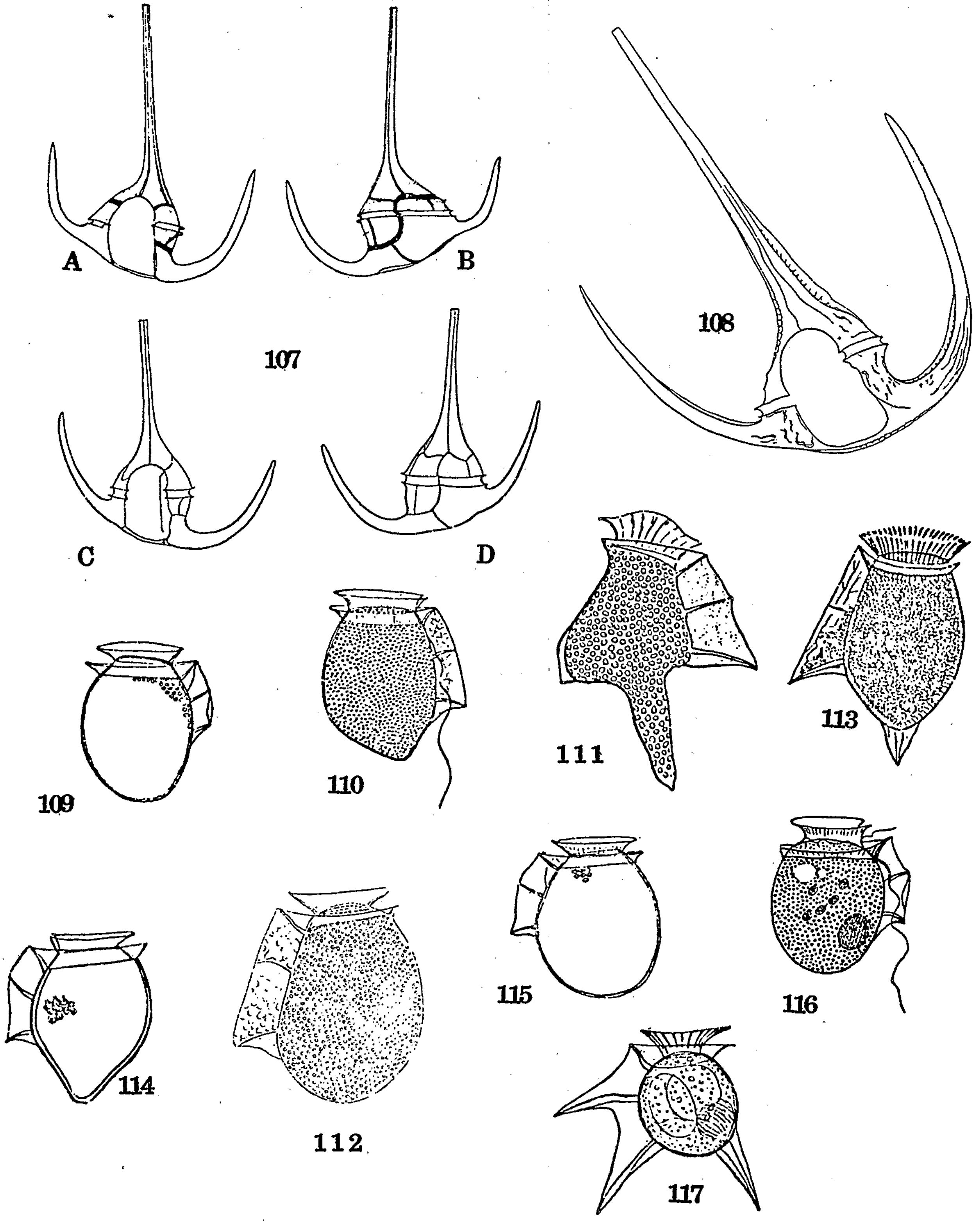
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Figure 118. *Ptychodiscus brevis* (Davis) Steidinger. Drawing by H. Marshall.

Figure 119. *Amphisolenia bidentata* Schröder. Drawing by D. L. Miller.

Figure 120. *Gonyaulax tamarensis* Lebour. Ventral (a), dorsal (b), epitheca (c), and hypotheca (d) views. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937). Note: The epithecal view presented in this original illustration is actually a mirror image of the correct pattern (Loeblich and Loeblich, 1975).

Figure 121. *Gonyaulax spinifera* (Claparede et Lachmann) Diesing. Ventral (b) and dorsal (a) views. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937).

Figure 122. *Gymnodinium splendens* Lebour. Ventral view. Redrawn with permission of Peter H. Campbell (Campbell, 1973).

Figure 123. *Gyrodinium spirale* (Bergh) Kofoid et Swezy. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1933).

Figure 124. *Heterocapsa triquetra* (Ehrenberg) Stein. Reprinted with permission of Peter H. Campbell (Campbell, 1973).

Figure 125. *Katodinium rotundatum* (Lohmann) Loeblich III. Reprinted with permission of Peter H. Campbell (Campbell, 1973).

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Figure 128. *Oxytoxum scolopax* Stein. Reprinted with permission of A. Asher and Company (Paulsen, 1908).

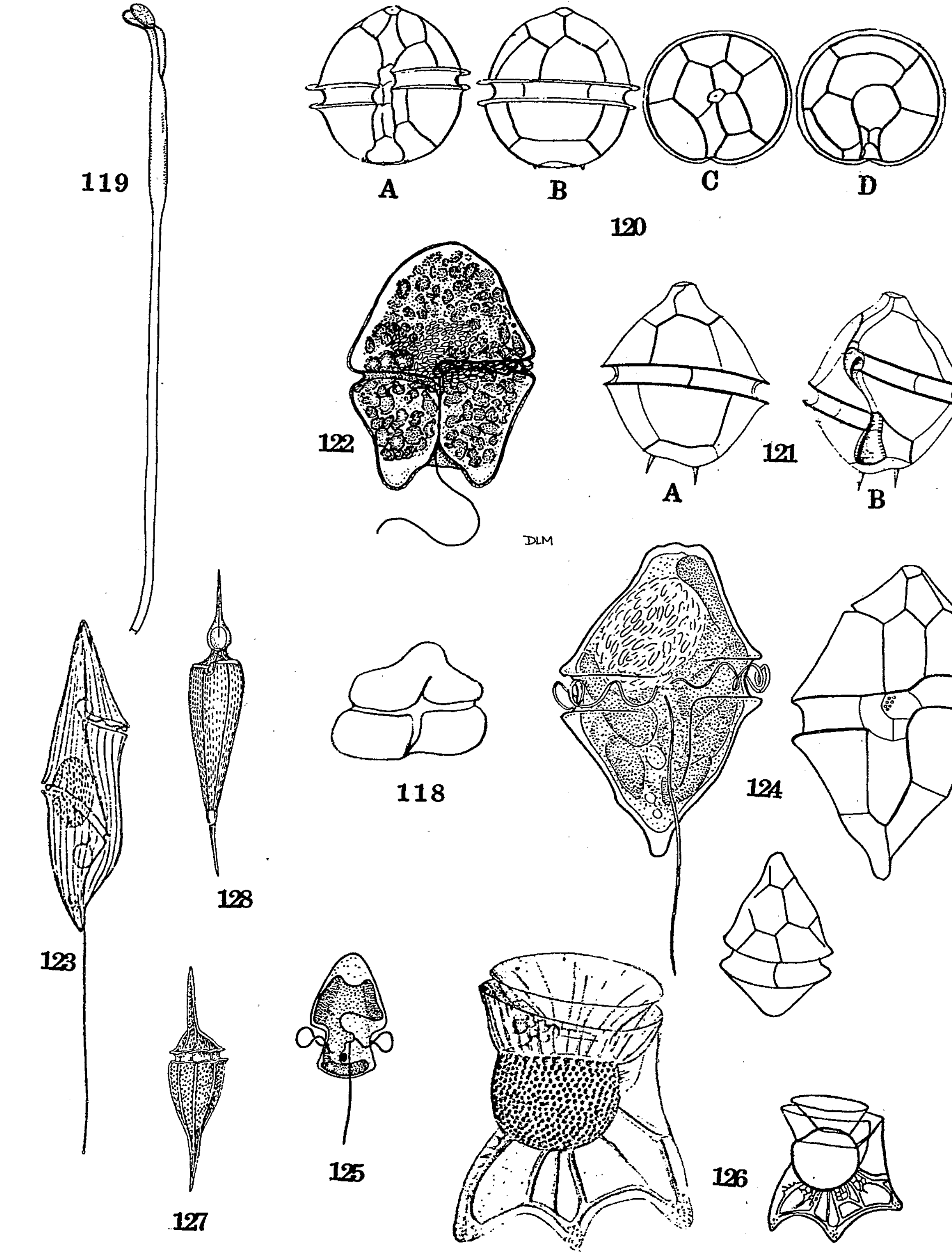
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Figure 129. *Prorocentrum aporum* (Schiller) Dodge. Reprinted with permission of J. E. Dodge (Dodge, 1974).

Figure 130. *Prorocentrum balticum* (Lohmann) Loeblich III. Reprinted with permission of J. D. Dodge (Dodge, 1974).

Figure 131. *Prorocentrum gracile* Schütt. Reprinted with permission of J. D. Dodge (Dodge, 1974).

Figure 132. *Prorocentrum micans* Ehrenberg. Reprinted with permission of J. D. Dodge (Dodge, 1974).

Figure 133. *Prorocentrum minimum* (Pavillard) Schiller. Various shapes. Reprinted with permission of J. D. Dodge (Dodge, 1974).

Figure 134. *Protoperidinium brevipes* (Paulsen) Balech. Ventral (a), dorsal (b), epithecal (c), and hypothecal (d) views. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937).

Figure 135. *Protoperidinium claudicans* (Paulsen) Balech. Ventral (a) and dorsal (b) views. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937).

Figure 136. *Protoperidinium conicum* (Gran) Balech. Ventral (a), dorsal (b), epitheca (c), and hypotheca (d) views. Reprinted with permission of Marine Biological Association of U.K. (Lebour, 1925).

Figure 137. *Protoperidinium depressum* (Bailey) Balech. Reprinted with permission of Marine Biological Association of U.K. (Lebour, 1925).

Figure 138. *Pyrocystis fusiformis* Wyville-Thomson et Blackman. Vegetative cell. Original drawing by D. L. Miller.

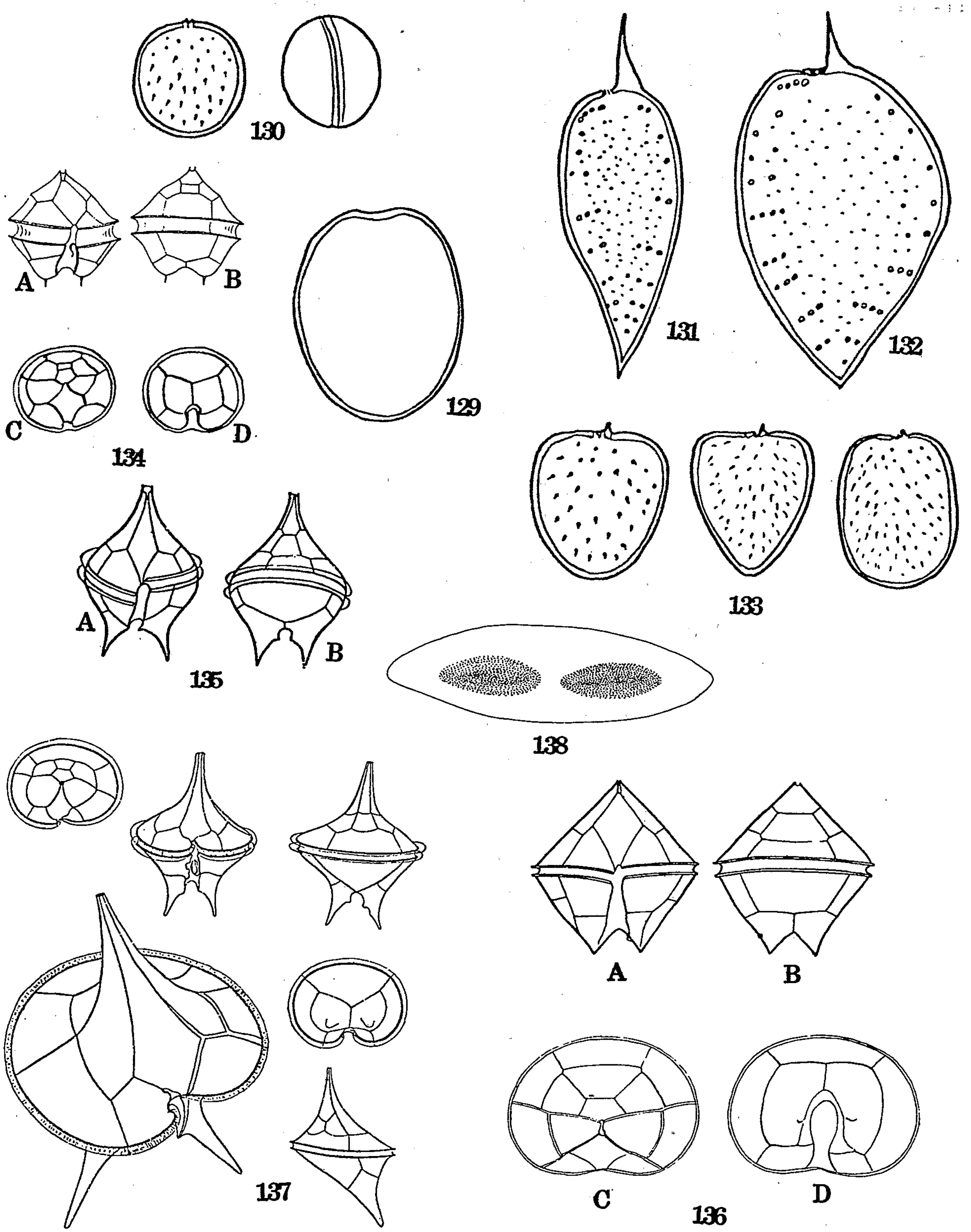
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Figure 139. *Protoperidinium leonis* (Pavillard) Balech. Ventral (a), dorsal (b), epitheca (c), and hypotheca (d) views. Reprinted with permission of the Marine Biological Association of the U.K. (Lebour, 1925).

Figure 140. *Protoperidinium oceanicum* (Van Höffen) Balech. Different views. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937).

Figure 141. *Protoperidinium pallidum* (Ostenfeld) Balech. Ventral (a) and dorsal (b) and epithecal (c) views. Reprinted with permission of the Marine Biological Association of the U.K. (Lebour, 1925).

Figure 142. *Protoperidinium pellucidum* (Bergh) Schütt. Ventral (a), dorsal (b), epithecal (c), and hypothecal (d) views; (e) A variation in cell shape. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937).

Figure 143. *Protoperidinium pentagonum* (Gran) Balech. Ventral (a), dorsal (b), epitheca (c), and hypothecal (d) views. Reprinted with permission of the Marine Biological Association of the U.K. (Lebour, 1925).

Figure 144. *Protoperidinium steinii* (Jorgensen) Balech. Ventral (a), dorsal (b), epithecal (c), and hypothecal (d) views. Reprinted with permission of Marine Biological Association of the U.K. (Lebour, 1925).

Figure 145. *Protoperidinium oblongum* (Aurivillius) Parke et Dodge. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1937).

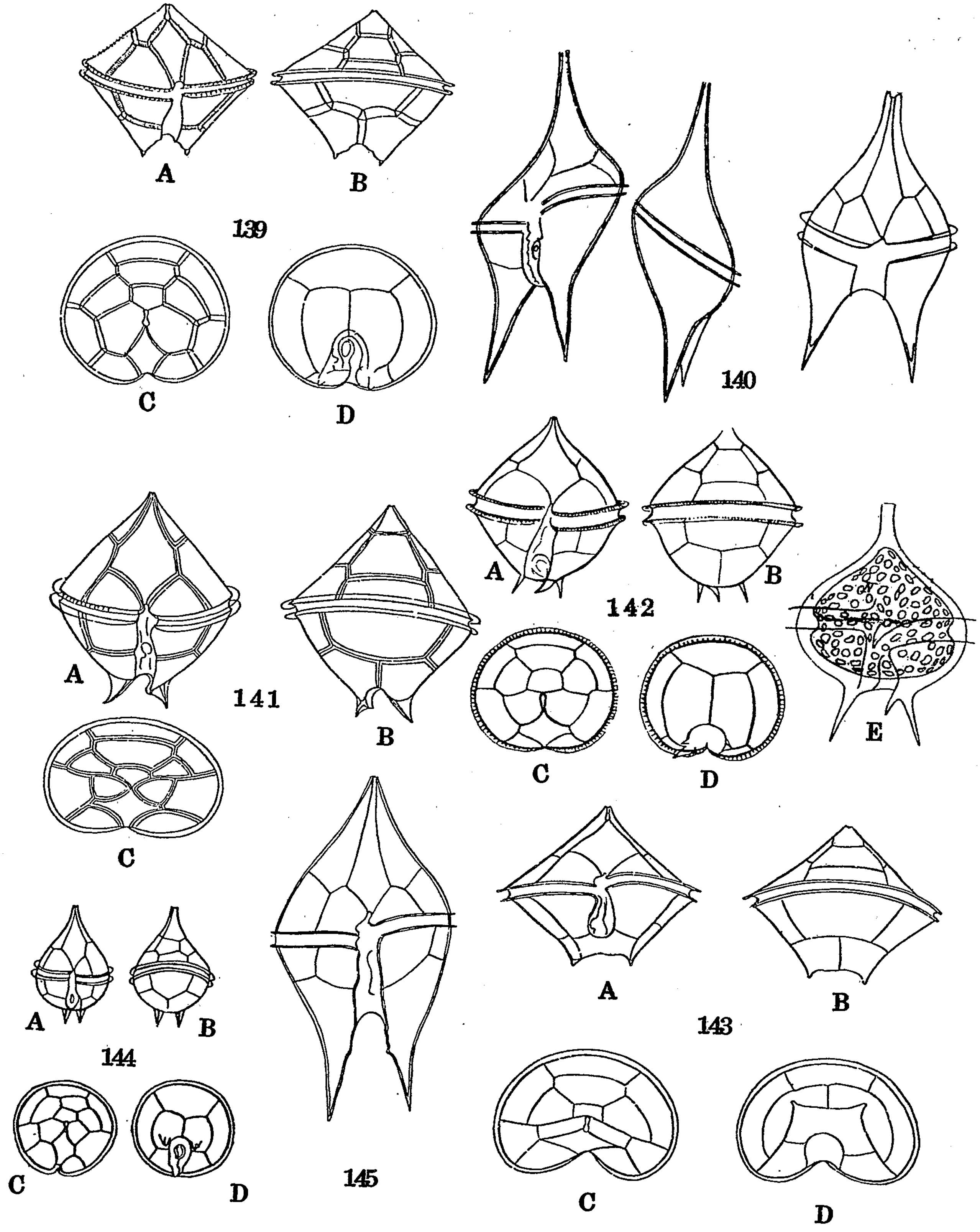
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Figure 146. *Calciosolenia murrayi* Gran. Reprinted with permission of the Centre National de la Research Scientifique (Trégouboff and Rose, 1957).

Figure 147. *Cyclococcolithus leptopora* (Murray et Blackman) Kamptner. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1930).

Figure 148. *Emiliania huxleyi* (Lohmann) Hay et Mohler. Reprinted with permission of Johnson Reprint Corporation (Schiller, 1930).

Figure 149. *Rhabdosphaera claviger* Murray et Blackman. Reprinted with permission of the Centre National de la Researche Scientifique (Trégouboff and Rose, 1957).

Figure 150. *Syracosphaera pulchra* Lohmann. Drawing by D. L. Miller.

Figure 151. *Merismopedia punctata* Meyen. Reprinted with permission of University Press of Virginia (Humm, 1978).

Figure 152. *Chroococcus limneticus* Lemmermann. Reprinted with permission of University Press of Virginia (Humm, 1978).

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Figure 154. *Microcystis elebans* Kützing. Reprinted with permission of University Press of Virginia (Humm, 1978). Redrawn by D. L. Miller.

Figure 155. *Gomphosphaeria aponina* Kützing. Cell colonies. A and B. Drawings by H. Marshall. C. Reprinted with permission of University Press of Virginia (Humm, 1978).

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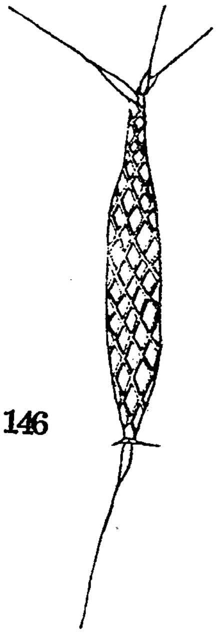

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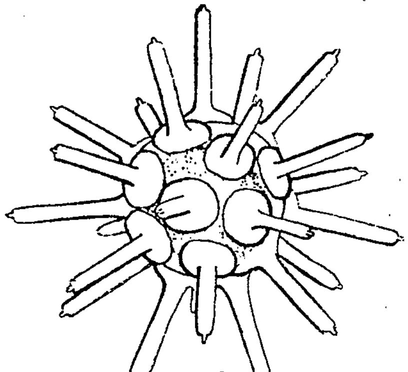

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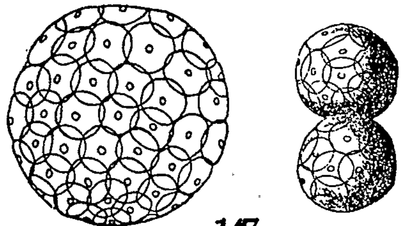

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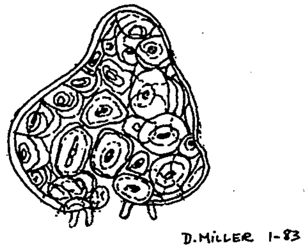

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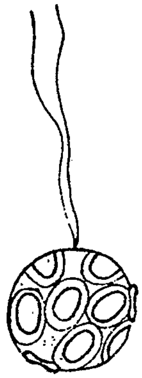

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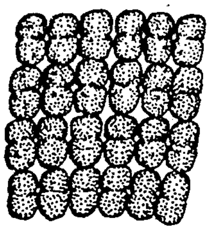

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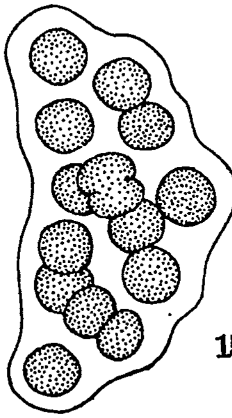

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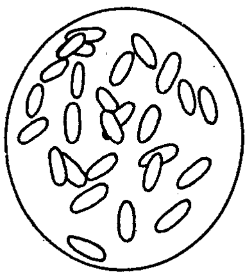

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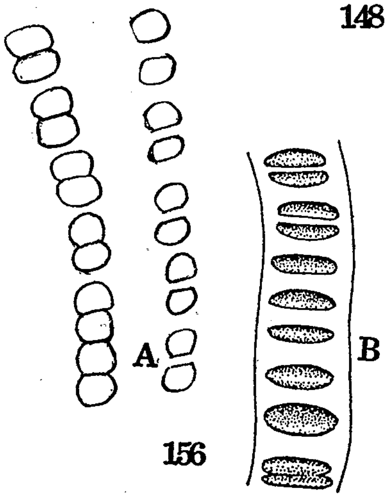

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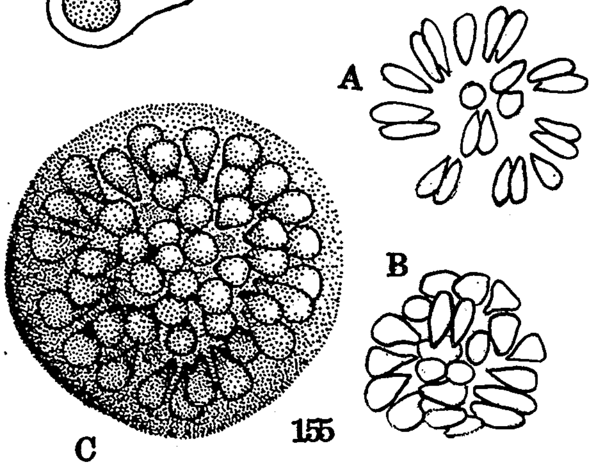

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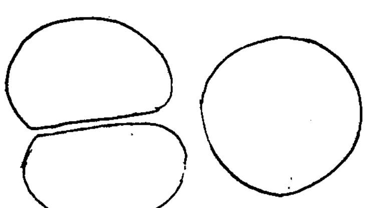

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Figure 160. *Synechococcus* sp. A. Reprinted with permission of University Press of Virginia (Humm, 1978). B. Drawn by H. Marshall.

Figure 161. *Chroomonas amphioxeia* (Conrad) Butcher. Reprinted with permission of Peter H. Campbell (Campbell, 1973).

Figure 162. *Cryptomonas pseudobaltica* Butcher. Reprinted with permission of Peter H. Campbell (Campbell, 1973).

Figure 163. *Pyramimonas micron* Conrad et Kufferath. Reprinted with permission of Peter H. Campbell (Campbell, 1973).

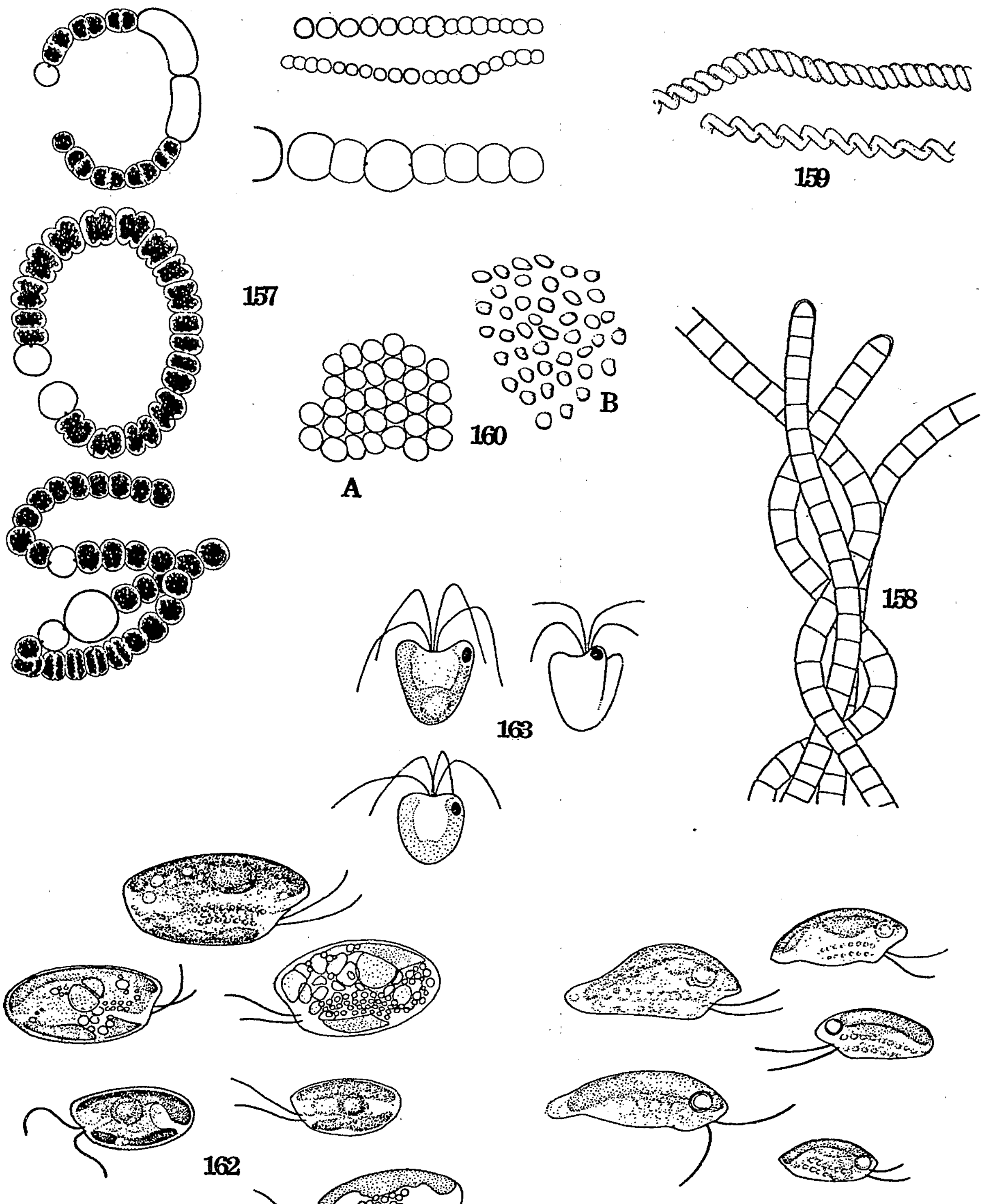
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Figure 164. *Tetraselmis gracilis* (Kylin) Butcher. Reprinted with permission of Peter H. Campbell (Campbell, 1973).

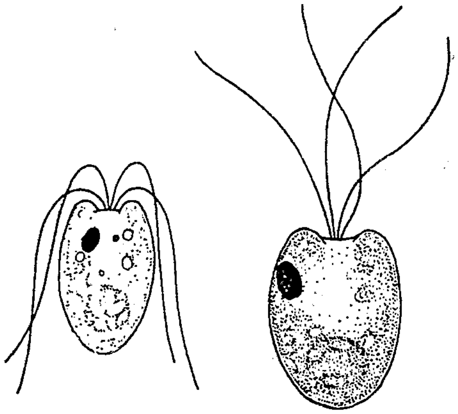
Figure 165. *Chlorella marina* Butcher. Drawing by D. L. Miller.

Figure 166. *Chlorella salina* Butcher. Drawing by D. L. Miller.

Figure 167. *Nannochloris atomus* Butcher. Drawing by D. L. Miller.

Figure 168. *Euglena proxima* Dangeard. Reprinted with permission of Peter H. Campbell (Campbell, 1973).

Figure 169. *Eutreptia lanowii* Steuer. Reprinted with permission of Peter H. Campbell (Campbell, 1973).



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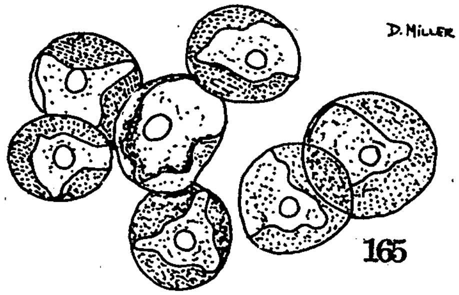

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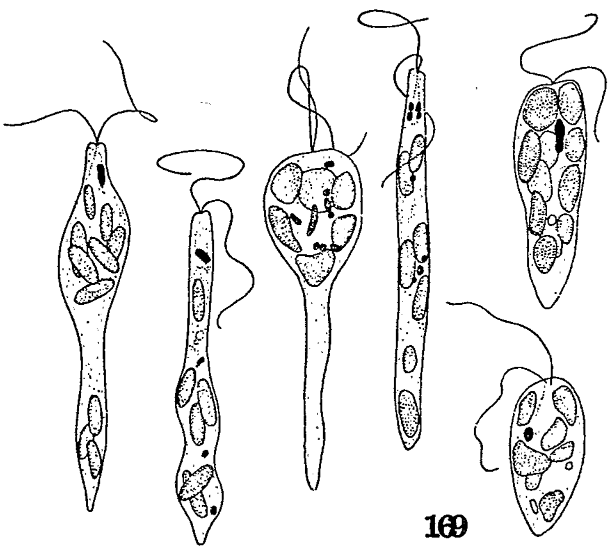

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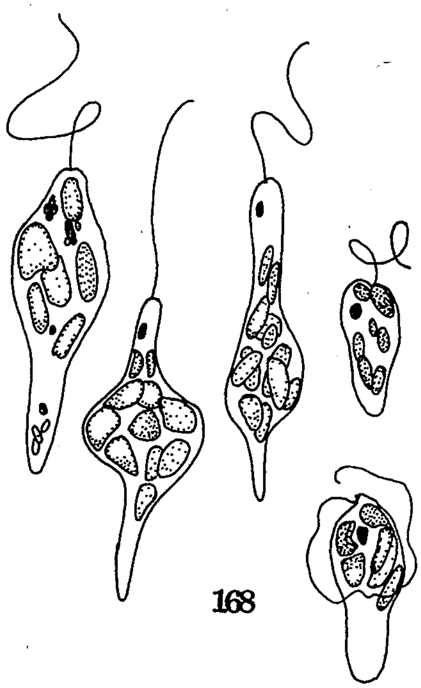

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GLOSSARY

acute: Ending in a sharp point.

akinete: Single celled, non-motile resting spore, common in filamentous cyanophyceae.

annular: Ringlike, having the form of a ring.

antapex: In a motile dinoflagellate, the posterior end of the hypocone or hypotheca.

antapical: Away from the apical region; in dinoflagellates commonly used in reference to antapical horns that arise from the hypotheca.

antapical plate: The plate, or one in a set of plates, of the antapex in an armored dinoflagellate.

anterior: In reference to dinoflagellates, that part of the cell that is in the direction of movement.

anterior intercalary plates: In armored dinoflagellates, the plates located between the apical and precingular plates.

aperture: In diatoms, refers to the space between adjacent cells in a chain.

apex: The tip, or highest point; usually refers to the anterior end, the end in the direction of forward movement.

apical axis: The longitudinal axis of the diatom valve; the breadth or width of the diatom is the diameter along the apical axis in a centrales diatom, or the distance along the apical axis in a pennales diatom.

apical plate: The plate, or one of a set of plates, of the apex in an armored dinoflagellate.

apiculus: A large, marginal nodule, containing a pore, often found near the valve margin of centric diatoms (plural, apiculi).

areola: Minute opening, a rounded or polygonal area or cavity in the wall structure of diatom cell wall (plural, areolae).

areolation: Presence of areolae; openings.

armored: Dinoflagellates possessing a cellulose wall composed of valves, or plates, that may have surface markings.

ascending spiral: In dinoflagellates, when the girdle is displaced so the right end is above the left. Also referred to as a right handed spiral. Opposite to descending spiral.

auxospore: In diatoms, the cell (zygote) formed by sexual reproduction, or a vegetative cell that expands in size.

basal ring: In silicoflagellates, the central part of the siliceous skeleton.

benthic: Refers to the bottom region of oceans, the continental shelf and other water habitats.

bifurcate: Divide into two parts.

bloom: A large and sometimes rapid growth of phytoplankton, often associated with hypoxic conditions and giving a distinct color to the water.

boreal: Pertaining to the northern temperate forms, but not the Arctic species.

bulbous: Shaped like a bulb; having a prominent and rounded end.

central nodule: The thickening on the inner face of the wall of some diatoms that separates a pair of rapheal fissures.

centrales: A division of diatoms where the cells have a radiating or concentric sculpture around a point or points, without a raphe or pseudoraphe (adj. centric).

chloroplast: Cell organelle containing photosynthetic pigments.

chromatophore: A colored body in a cell which has a pigment other than chlorophylll that is predominant.

cingulum: Part of a diatom thecal girdle; may be composed of connecting and intercalary bands; in dinoflagellates synonymous with girdle, contains the transverse flagellum.

clavate: Club shaped.

coccolith: A calcium carbonate structure that with other coccoliths collectively form an external envelop of a coccolithophore cell. They consist of separate elements formed by the Golgi apparatus within the cell; they are diverse in structure and appearance, representing one basis for the taxonomy within this group.

coccolithophorid: The single cell, or protoplast, of one of the coccolith forming Haptophyceans (syn. coccolithophore).

conical: Cone-shaped.

connecting band: In diatoms, a single unit of a girdle, a hoop-shaped structure attached to a diatom valve; may be separated from valve by additional formation of intercalary bands.

cordate (cordiform): Heart shaped.

cosmopolitan: Wide distribution in world oceans.

costa: An internal or external rib-like thickening on a diatom valve. May contain punctae (plural, costae).

cuneate: Tapering to a point at the base, wedge-shaped.

cyst: The resting stage or spore of a unicellular alga.

descending spiral: In dinoflagellates, when the girdle is displaced so the right end is below the left. Also referred to as a left handed spiral. Opposite to ascending spiral.

discoid: Having the form of a disk, disk-shaped.

dorsal: Reference to the back; in dinoflagellates that part of the cell opposite the side containing the sulcus. See ventral.

dorsi-ventral: Having distinct dorsal and ventral sides.

endosymbiont: An organism living symbiotically within the cell or another organism.

epicone: In unarmored dinoflagellates, the anterior portion of the cell, separated from the posterior half (hypocone) by the cingulum (girdle).

epitheca (epivalve): In diatoms, the larger of the two halves, that is part of the diatom frustule, composed of a valve and cingulum; or in armored dinoflagellates refers to the area anterior to the girdle, and is usually composed of plates.

epivalve: See epitheca.

equatorial: Reference to the median region, in dinoflagellates determined in relation to an axis from apex to antapex.

femtoplankton: Plankton with a size range of 0.02 to 0.2 μm. This category would include viruses.

filiform: Thread-like.

frustule: The diatom cell wall, or exoskeleton; composed of two opposing silicious valves, each valve may have one or more connecting bands. Often compared to the two halves of a petri dish.

fusiform: Rounded and tapering from the middle toward each end, spindle-shaped.

girdle: Encircling, or middle; in diatoms the region between the epivalve and hypovalve; in dinoflagellates the transverse groove containing the transverse flagellum, and synonymous with cingulum, and the transverse furrow.

girdle band: See connecting band.

girdle view: Side view of a diatom. The girdle is exposed.

gullet: Reference to the tube-like opening found in the euglenoids; within its margin the flagella originate.

heterocyst: An enlarged, thick-walled cell common to the cyanophyte trichome.

horn: Structured process common to many dinoflagellates (e.g., *Ceratium* spp.). Right and left horns distinguished by their location in reference to the sulcus; apical horn associated with apical region of the epitheca, antapical horns with the hypotheca.

hyaline: Clear, transparent.

hypocone: In unarmored dinoflagellates, the posterior portion of the cell, separated from the anterior half (epicone) by the cingulum (girdle).

hypotheca (hypovalve): In diatoms, the smaller of two valves, that is part of the diatom frustule, composed of a valve and cingulum; or in armored dinoflagellates, the area posterior to the girdle, and is usually composed of plates.

infraspecific divisions: Refers to classification below the species level (e.g., sub-species, variation, form).

intercalary bands: Additional intermediate bands that form between the connecting bands and valve of certain diatoms, producing an inrease of length along the pervalvar axis.

keel: A raised, longitudinal ridge common to certain diatoms bearing the raphe.

lanceolate: Shaped like the head of a lance, tapering more sharply to one end from a rounded base.

lateral: Pertaining to the side; in contrast to dorsal or ventral.

left antapical horn: In dinoflagellates, the antapical horn located on the left side. See definition for left side.

left handed spiral: See descending spiral left side: In dinoflagellates, when viewing from the dorsal surface, with the apical end forward, the left and right sides may be determined. The dorsal surface being the side opposite the sulcus.

linear: A single line, or lines; or like a line, long and narrow.

list: A fine membrane-like extension of the cell, often found associated with the girdle and sulcus margin in certain dinoflagellates.

littoral: A region along the shore; reference to living on or near the shore.

longitudinal flagellum: In dinoflagellates, the flagellum that arises from a sulcal pore and is directed posteriorly along the sulcus.

longitudinal furrow: Synonymous with sulcus.

mantle: See valve mantle.

microplankton: Plankton with a size range of 20 to 200 µm.

nanoplankton: Plankton having a size range between 2.0 and 20.0 µm.

neritic: Reference to the part of the ocean that is associated with the continental shelf; that part between the coastal low tide mark to the shelf margin.

net plankton: Those plankton typically captured in nets, having a size greater than 50 µm.

nodule: A small thickening, rounded to conical, in the valve walls of many pennate diatoms, usually includes a central and two terminal nodules.

oblique: slanting, not straight up or down, or straight across.

obovoid: Inversely ovoid, with the broader end anterior, or outermost.

obtuse: Not sharp; blunt, or rounded.

oceanic: Marine waters seaward of the continental shelf margin.

oval: Ellipse-shaped, equally rounded at the ends.

ovate: Egg-shaped.

ovoid: Oval, with one end more pointed than the other.

panduriform: Fiddle-shaped.

parietal: Attached to the inside wall of the cell or hollow organ.

pelagic. Pertaining to the oceans, water above the bottom, divided into neritic and oceanic areas.

pennales: A division of diatoms where the cells are typically bilaterally symmetrical and have a valve outline similar to a boat, or rod (adj. pennate).

pervalvar axis: The axis through the center point of two diatom valves. The length of the cell is the distance along the pervalvar axis.

picoplankton: Plankton with a size range of 0.2 to 2.0 µm. This category would include bacterioplankton.

plastid: The cell organelle that contains the photosynthetic pigments; the chloroplast.

plate tabulation: Refers to the orderly classification of thecal plates in armored dinoflagellates, and represents the basis for their classification. The plates are arranged in specific groups, in an encircling pattern around the cell, these are the apical ('), precingular ("), girdle or cingulars (c), sulcals (s), postcingular ("'), and antapical ("") plates. The plate formula presents the number of plates in each category, followed by the symbol for each category. Since some forms have additional intercalary plates between the basic five groups, they may also be inserted in the plate formula. The number followed by the letter "a" is used if the plates are anterior and between the apical and precingular plates, or the letter "p", if posterior and between the postcingular and antapical plates. For instance, the plate tabulation for the genus *Gonyaulax* is 3-4', 0-4a, 6", 6c, 5-10s, 5-6"', 1p, 1"".

plate view: Reference to the view commonly presented by one of the opposing valves in the genus *Prorocentrum*.

poroids: Minute openings, or areas, within the areolae of diatom valves, or the minute depressions found in the thecae covering of some dinoflagellates.

postcingular plates: In armored dinoflagellates, the epithecal plates next to the cingulum.

posterior: In dinoflagellates, toward the antapex.

posterior intercalary plates: In armored dinoflagellates, the plates between the postcingular and antapical plates.

precingular plates: In armored dinoflagellates, the epithecal plates next to the cingulum.

process: A protuberance, often similar to a conical shaped needle, extending outward from the cell, may be hollow, solid, simple, or branching.

protoplast: The cell and its contents, exclusive of the cell covering or cell wall.

pseudoraphe: Clear area on valve between rows of striae or costae in some pennate diatoms.

puncta: A thin area, or a depression in diatom valves. A row of punctae will form a stria (plural, punctae).

pyriform: Pear-shaped.

quadrate: Square, or rectangular.

raphe: A longitudinal fissure, or pair of fissures, on one or both valves of some pennate diatoms.

resting spore: A period of cell reorganization and temporary dormancy; often initiated by adverse or changing environmental conditions, with the potential for the cell to continue growth with the return of favorable conditions.

right antapical horn: In dinoflagellates, the antapical horn located on the right side. See definition for left-right side.

right handed spiral: See ascending spiral.

right side: See left side definition.

rosette: A circular arrangement of large areolae found in the center of the valve of certain centrales diatoms.

rhomboid: Shaped like a parallelogram with equal opposite sides, but not a rectangle.

sculptured: Not smooth, a valve or thecal surface containing markings or cavities.

seta: Long, hollow, thread-like, often delicate outgrowth arising from the valve margin of various diatoms (plural, setae).

sigmoid: Shaped like the letter S.

silicoflagellate: Refers to certain chrysophytes having a silica cytoskeleton, formed by a framework of silicious rods, including spines in some species.

spindle: Shaped like a spindle, rounded in the center and tapering at each end.

spine: A small process.

spinule: A small spine, may contain a pore, often found along the margin of certain centrales diatoms. Cells are often connected by gelatinous threads that pass through spinules of adjacent valves.

stria: A linear orientation of areolae or puncta, common to a diatom valve; in light microscopy appears as a fine line (plural, striae).

sub-hemispherical: Slightly hemispherical in shape.

sulcus: A longitudinal groove or furrow in dinoflagellates, partially containing the longitudinal flagellum; located on ventral side, dividing the cell into left and right halves. Synonymous with longitudinal furrow.

tabular: Having the form of a tablet; flat and thin.

temperate: That area between the tropics and polar circle.

thecal plates: The outer cell covering of many phytoflagellates is referred to as the theca, which is found in some species to be subdivided in plate-like units.

transapical axis. The transverse axis of the diatom valve, which passes through the pervalvar axis and across the apical axis.

transverse groove. The girdle, or cingulum found in certain dinoflagellates that contains the transverse flagellum, and separates the epicone or epitheca from the hypocone, or hypotheca.

trichocyst: A cell organelle, that can eject hair-like substances (syn. ejectosome).

trichome: Thread-like series of cells common to the cyanobacteria (cyanophyceae) that may, or may not be enclosed in a gelatinous sheath.

truncate: Having no apex; as when a cone or pyramid shaped object has its apex cut off by a transverse line.

ultraplankton: A general category, referring to plankton with a size range of 0.5 to 10.0 µm.

unarmored: In dinoflagellates, cells that do not have an outer cellulose wall composed of valves, or plates.

valve: In diatoms, one of the two halves of a diatom frustule, found in the epitheca or hypotheca. In some dinoflagellates, as in *Prorocentrum*, one of two opposite halves of the cell.

valve face: Part of the valve surrounded by the valve mantle; what is normally seen in a valve view.

valve mantle: In diatoms, that portion of the valve seen in the girdle view that is usually differentiated by slope.

valve view: In diatoms, surface view of the valve face.

velum: A thin perforated layer of silica over an areola.

ventral: In dinoflagellates, refers to side having the sulcus; opposite to dorsal.

ventral area: In dinoflagellates, the plate area associated with the ends of the girdle; in *Ceratium*, the ventral area is prominent and generally broad, with the sulcus representing a narrow furrow along its left border.

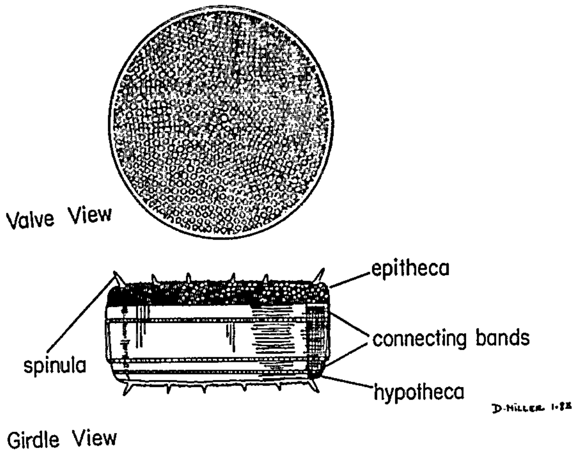


Figure 170. Representative valve and girdle views of a centric diatom.

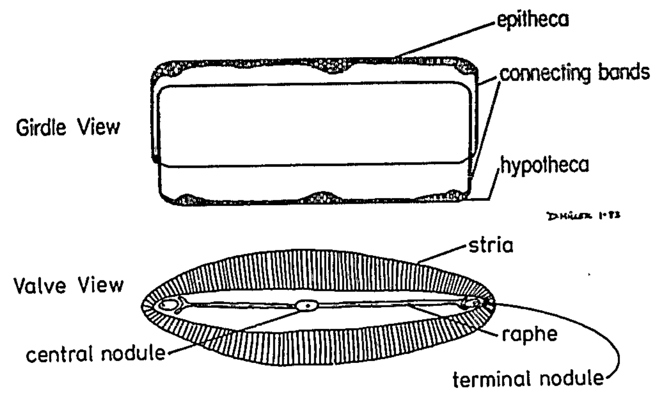


Figure 171. Representative valve and girdle views of a pennate diatom.

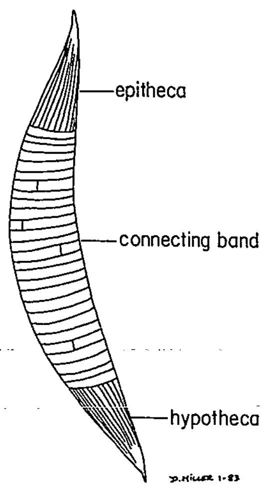


Figure 172. A *Rhizosolenia robusta* cell in girdle view showing numerous connecting bands.

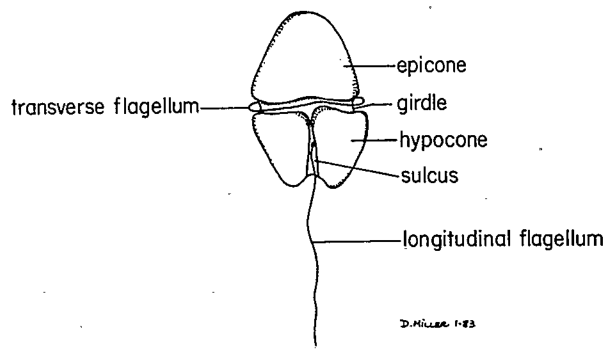


Figure 173. A representative view of a non-armored dinoflagellate.

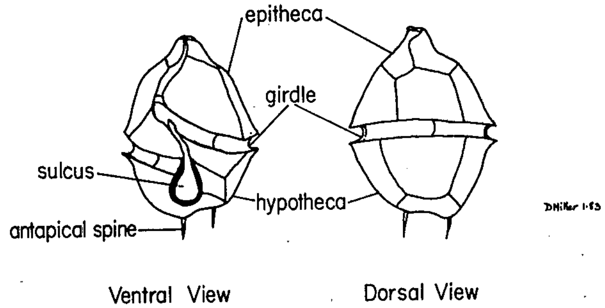
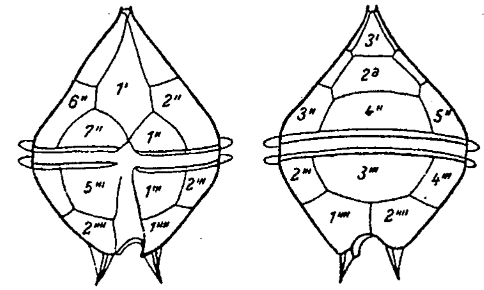


Figure 174. Representative ventral and dorsal views of an armored dinoflagellate.



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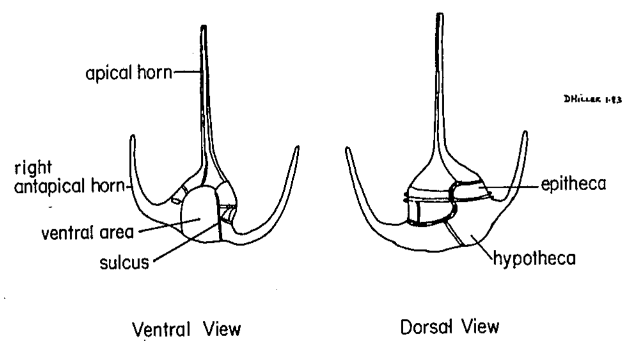
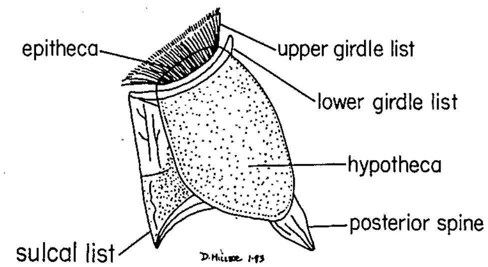


Figure 176. Ventral and dorsal views of a representative *Ceratium* species.



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